DOCUMENT RESUME

ED 132 053	SE 021 749
TITLE	National Science Foundation-Supported Science Education Materials: Problems in Evaluation, Distribution, and Monitoring. Report to the Congress by the Comptroller General of the United States.
INSTITUTION	Comptroller General of the U.S., Washington, D.C.
SPONS AGENCY	Congress of the U.S., Washington, D.C.
REPORT NO	HRD-76-134
PUB DATE	20 Oct 76
NOTE	79p.; Follow-on to ED 113 281
EDRS PRICE	MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS	*Curriculum Development; *Curriculum Evaluation; Curriculum Problems; Elementary Secondary Education; Evaluation Needs; *Federal Programs; Policy Formation; *Program Administration; Projects; *Science Education; *Social Sciences
IDENTIFIERS	*National Science Foundation

ABSTRACT

After a study of ten science education projects receiving NSF financing, the GAO concludes that evaluation of educational materials needs more attention, distribution efforts should be strengthened, and a need exists for more active and systematic project monitoring. Chapter 1 of this document gives a general review of NSF activities and funding policies; Chapters 2, 3, and 4 respectively report details of evaluation, distribution, and monitoring efforts of the ten science education projects; and Chapter 5 discusses the scope of the NSF review. Appendices list the ten NSF-supported science education projects (along with a general project description, types of materials produced by that project, and amount of funding for each project), NSF responses to the GAO recommendations, and names of NSF officials responsible for administrative activities discussed in the report. (DT)

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REPORT TO THE CONGRESS

UNITED STATES GENERAL ACCOUNTING OFFICE

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

National Science Foundation-Supported Science Education Materials: Problems In Evaluation, Distribution, And Monitoring

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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The Foundation needs to emphasize more evaluation of the education materials that it finances. Most materials' evaluations did not sufficiently demonstrate that students will acquire the desired educational outcomes.

Also, more consideration should be given to potential materials' distribution problems (too costly or too innovative) that might limit acceptance of the materials by school systems. There were distribution problems with many materials; however, the Foundation did not have a system to collect data on the use of the materials that would have helped to determine the effect of the problems.

Finally, the Foundation's oversight of projects needs to be more active and systematic to identify and quickly correct administrative weaknesses in projects for developing educational materials.

HRD-76-134

OCT. 20, 1976

SE 021 749

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-133183

To the President of the Senate and the
Speaker of the House of Representatives

This report describes the evaluation, distribution, and monitoring of science education materials, developed through 10 projects supported by the National Science Foundation, and recommends improving the Foundation's policies and procedures for these activities. It is a follow-on to our October 14, 1975, report, entitled "Administration of the Science Education Project 'Man: A Course of Study' (MACOS)" (HWD-76-26), which described Foundation efforts in supporting the development, evaluation, and distribution of the project materials. In that report, recommendations were made to better insure sound business practices in administering science education projects. Evaluation, distribution, and monitoring problems were noted during the project review, but suggestions for improvements were largely withheld because additional projects needed examination.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Management and Budget, and to the Director, National Science Foundation.

Elmer B. Staats

Comptroller General
of the United States

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ABBREVIATIONS

GAO	General Accounting Office
MACOS	"Man: A Course of Study"

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NATIONAL SCIENCE FOUNDATION-SUPPORTED SCIENCE EDUCATION MATERIALS: PROBLEMS IN EVALUATION, DISTRIBUTION, AND MONITORING

DIGEST

The National Science Foundation provided $259 million to academic and nonprofit institutions for developing science education materials (such as teaching guides, textbooks, films, and video tapes) during 1956-75 for use by schools from kindergarten through college. It also provided about $88 million, for activities such as training teachers, to help put selected materials to use.

The Congress, questioning the need for the materials the Foundation had financed and whether the materials had an unfair competitive advantage over those developed by the private sector, discontinued, in fiscal year 1976, financing of activities to help put materials to use.

GAO studied 10 projects receiving Foundation financing of about $17 million for development, and about $9 million for implementing the materials. The Foundation needs to:

--Emphasize evaluation of science materials it finances to better assess their education value.

--Become more concerned with the need for the materials and potential distribution problems (such as materials' cost) by involving potential users and firms that will distribute the materials (commercial publishers) in the development stage.

--Establish a better monitoring (oversight) system to identify and correct projects' administrative weaknesses.

Evaluation is the principal way to determine if the objectives of educational materials are being met. So, the Congress should:

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—Require the Foundation to identify evaluation funds in its annual budget request.

—Specify amounts for evaluation in annual funding legislation. (See pp. 4 to 27.)

Because the Congress discontinued funds for putting materials to use, materials' distribution will be more dependent on commercial publishers' interest in the materials. The Congress should advise the Foundation:

—Whether it should support the development of science education materials whose need has been demonstrated but which might not be attractive to publishers.

—What steps it should take to distribute these materials. (See pp. 28 to 48.)

Evaluation problems included:

—Foundation reliance on the developers to evaluate their materials who usually only obtained opinions of the materials and did not conduct formal objective testing to demonstrate the materials' worthiness in improving science education. (See pp. 10 to 14.)

—Lack of evaluation of the final version of some of the educational materials distributed. (See pp. 11 and 16.)

—Evaluation reports not always published and test results sometimes did not support claims made in promotional literature. (See pp. 14 to 17.)

To correct these problems, the Foundation Director should first issue an overall policy statement committing the Foundation to administrative and financial support of evaluating education materials and requiring its officials to become directly involved in planning and in overseeing the evaluations. Further, GAO recommends:

—Requiring that proposals sent to the Foundation requesting funds to develop educational materials contain a separate evaluation plan which states the materials' objectives in measurable terms, an evaluation design to show whether the objectives were accomplished, and a budget line item for evaluation.

—Developing guidelines for evaluating education materials that consider types and extensiveness of testing to aid Foundation officials, materials' developers, and evaluators in planning for evaluations.

—Requiring an evaluation report for all materials developed with Foundation financial support which should be thoroughly reviewed by the Foundation for accuracy and completeness and offered as part of the materials' sales package.

Distribution problems included:

—Many materials were too costly or too innovative to make them attractive to commercial publishers; also, these two factors could have reduced the materials' adoption by schools. (See pp. 29 to 38.)

—The Foundation rarely supported followup studies after the materials were distributed to determine the long term impact on students. It also did not routinely collect data to determine how extensively schools adopted the materials. (See pp. 38 to 42.)

To correct these problems, the Foundation Director first should require developers of educational materials to submit with their proposal to develop materials, a distribution plan providing specific data demonstrating the materials' need and identifying potential distribution problems (such as high cost). GAO also recommends:

—Including publishing representatives as reviewers of proposals to develop educational materials and including publishing representatives and potential users in periodic reviews of the materials during development. GAO previously recommended that potential users be included as proposal reviewers (MWD-76-26, Oct. 14, 1975).

—Establishing a system for providing Foundation management with data to assess the extent of use of educational materials it finances and "lessons learned" for future materials.

Finally, the unsystematic and sometimes inactive project monitoring was apparently resulting from no formal Foundation guidelines to aid its program managers in overseeing projects and the Foundation's "hands off" approach in allowing grantees maximum freedom to carry out a project. (See pp. 49 to 55.)

The Foundation Director should issue a policy statement providing for more active Foundation involvement in monitoring projects. He should also:

—Establish guidelines for active, systematic review that would include the frequency for using monitoring techniques and require documenting these activities.

—Establish progress report requirements that include: how often the reports are to be made, what format is to be used to report project milestones, how the Foundation's management can evaluate the progress of the project, and documentation showing how problems were resolved.

The Foundation agreed with the substance of GAO's recommendations and planned corrective actions. Although many of these were largely in the "thinking stage," in some instances the intended improvements may not be sufficient to adequately correct the problems identified. For instance, to correct evaluation problems, the Foundation:

—Plans to extend (in practice) an existing policy statement to satisfy GAO's recommendation for a formal evaluation policy statement. This may be sufficient for the Foundation, but other interested parties should be informed of the broader application to avoid misunderstanding. (See p. 22.)

—Will make sure that the purposes of educational materials are clear and explicit. However, GAO believes that objectives should be stated in measurable terms which is basic to evaluation and the Foundation should justify exceptions. (See p. 24.)

—Commented that formal evaluation reports may not be appropriate for every project. GAO believes that regardless of the extensiveness of the evaluation, an evaluation report should be available for potential users (such as school administrators and teachers) of the materials. (See p. 25.)

—Suggested referring interested parties to sources such as the National Technical Information Service to obtain evaluation reports. GAO believes having evaluation reports available through the distributor of the educational materials to be more convenient and timely. (See p. 25.)

To correct distribution problems the Foundation cited technical and practical problems in assessing the impact of educational materials it supports, but agreed to work on the problem. GAO further defined the type of data it believes is necessary which should largely resolve the Foundation's difficulties. (See p. 47.)

The Foundation agreed to establish monitoring policies and guidelines; however, too much reliance may be placed on periodic checks by a special review board rather than the officials directly responsible for daily project oversight. (See p. 56.)

CHAPTER 1

INTRODUCTION

The National Science Foundation is authorized under the National Science Foundation Act of 1950 (42 U.S.C. 1861 et seq.), as amended, to initiate and support, through contracts and other forms of assistance such as grants, basic scientific research and programs to strengthen scientific research potential and science education programs.

The Foundation's science education activities, administered by its directorate for science education, consist primarily of grant and fellowship programs to improve education for professional careers in science- and technology-based fields, improve scientific literacy, and increase the efficiency and effectiveness of educational processes. This report concerns the activities for improving science education by supporting the development of science education materials for use by school systems at the precollege (kindergarten through grade 12) and higher education levels.

Broad educational needs are identified by Foundation officials through informal means, such as conferences, Advisory Committee 1/ meetings, ideas from experts in the field, and internal expertise and formal means, such as proposals received and projects focused on problem and needs assessment.

The Foundation issues program and other special announcements which identify for the education and scientific communities the broad education areas where improvements are needed. The announcements for developing educational materials define the eligible organizations from which the Foundation will accept proposals and the academic grade levels and fields that the planned improvements should cover. Academic and nonprofit institutions are eligible to submit proposals. The proposals received are considered unsolicited and are usually sent outside the Foundation to peer reviewers who review them and

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1/The Advisory Committee for Science Education provides advice and recommendations concerning education activities to the Director of the Foundation, through the Assistant Director for Science Education. The Committee consists of from 9 to 12 members who are appointed by the Director for 1-year terms and are normally not reappointed for more than 3 consecutive terms.

comment on their merits. Accepted proposals are usually funded through grants made to colleges, universities, or educational associations or societies.

The Foundation's policy for distributing educational materials developed with its support provides for open competition among qualified and interested organizations. The distributor of the Foundation-supported educational materials as well as the distribution arrangements--either commercial or noncommercial--are selected by the grantee subject to Foundation approval.

Before fiscal year 1976 the Foundation also awarded grant funds, through a competitive process, for implementing major curriculums and other education materials at the precollege level to strengthen science and mathematics programs. The implementing grants provided for activities, such as awareness projects to furnish information to school decision-makers (such as principals and supervisors) about new materials and teacher projects to train teachers in the effective use of new educational materials. No similar Foundation program existed for implementing higher education projects it supported. Both Foundation-supported and non-Foundation-supported curriculums were eligible for precollege implementation support. For fiscal year 1976, funding for the precollege level implementation activities was curtailed by the Congress. The Foundation reassessed the need for the implementation activities as part of an overall evaluation of its precollege science education activities. Currently, the Foundation plans no further implementation activities.

Foundation officials estimated that during fiscal years 1956-75 over 750 educational projects received about $299 million for developing educational materials and approaches at the precollege and higher educational levels. Fifty-three of the projects were at the precollege level, which received about $196 million, and the remaining projects were at the higher education level, which received about $103 million. Grants for implementing materials from the precollege level projects totaled over $87.9 million.

We selected seven precollege level projects and three higher education projects funded for developing education materials and approaches to determine the adequacy of:

--Evaluations of the materials' effectiveness in improving science education.

--Distribution efforts for making the education materials available to school systems.

--Foundation techniques for monitoring the project grants.

In selecting the 10 projects for developing education materials and approaches, we included projects (1) funded under the broad objectives of the science education directorate, such as projects intended to improve education for professional careers in science (see p. 1), (2) ongoing as well as completed, (3) receiving large dollar amounts (5 projects received over $1 million for developing their materials) and those receiving small dollar amounts (1 project received about $72,600), and (4) administered through large universities, as well as those conducted by small colleges and nonprofit education and scientific associations.

As of June 30, 1975, Foundation funding for the 10 projects for developing educational products totaled about $17.2 million, with the earliest funding beginning in fiscal year 1962. Various grantees received over $9 million in Foundation funding for implementation activities related to using materials from six of the precollege level projects. Appendix I provides descriptive and funding data for the 10 projects.

Pursuant to a congressional request, we have already reported our findings for 1 of the 10 projects--the social studies elementary project. 1/ Certain aspects of this project, however, are also discussed in this report.

We have issued another report on developing and distributing Federal-supported education materials. 2/ The activities were supported by the National Institute of Education, Department of Health, Education, and Welfare. The management problems associated with the materials supported by the Institute, as discussed in that report, are similar to those discussed here.

1/"Administration of the Science Education Project 'Man: A Course of Study' (MACOS)" (Oct. 14, 1975, MWD-76-26).

2/"Educational Laboratory and Research and Development Center Programs Need To Be Strengthened," (B-164031(1) Nov. 16, 1973).

CHAPTER 2

EVALUATION OF EDUCATION MATERIALS NEEDS MORE ATTENTION

The National Science Foundation needs to emphasize more evaluation of education materials to better insure the educational value of materials it supports for use by school systems. Evaluation is the principal way the Foundation, materials' developers, school officials and other users can determine the education materials' worthiness in improving science education. The Foundation has no formal guidelines specifying the types of testing and evaluations for educational materials developed with its support. Although generally recognizing the need for evaluation, the Foundation has relied on its grantees to establish and implement their own evaluation schemes.

The grantees for each of the 10 projects had provided for some evaluation of the education materials developed. However, for six of the projects this usually consisted of only obtaining teachers', students', or other reviewers' opinions of the materials which did not sufficiently demonstrate the materials' effectiveness in training students and/or teachers. More formal objective testing was performed for four projects. However, we reviewed the results for two of the four projects and found some results questionable because of testing design and procedural problems. Also, the final version of some of the educational materials distributed was not tested.

Most of the evaluations supported by the Foundation were conducted through the project staff that developed the materials. The Foundation directly funded a separate independent followup evaluation for the final materials developed by one of the projects. The evaluation is scheduled for completion in January 1977--about 6 years after the materials were commercially distributed.

An evaluation report on the materials' worthiness should be available to aid prospective users. Four of the projects had evaluation reports but they were not listed on distributors' price lists as part of the materials for sale. Three of these reports were incomplete because they either did not report on the total or final test results or other factors which could have affected testing outcome, such as using incomplete test data. Also, some promotional claims for the materials developed were not supported by the projects' evaluation reports.

The Congress is concerned over the merit of educational materials supported by the Foundation. The problems in evaluation we noted demonstrate the need for improved evaluation of the education materials.

EVALUATION NEEDS EMPHASIS

The Foundation has no formal guidelines specifying the types of testing and evaluations for educational materials developed with its support. The Foundation's instructions (program announcements) to grantees for preparing proposals to develop educational materials provided little, if any, instruction on evaluating materials. Also, the cost of evaluation did not always appear as a line item in a project's budget, planned evaluations were sometimes eliminated when grant funding was reduced, and the Foundation's program managers (responsible for project monitoring) were not always familiar with the types of testing or knowledgeable of the test results.

Program announcements

The Foundation's fiscal year 1976 precollege level announcement for developing education materials lists a number of essential components that the proposal should include, but the announcement is silent on requesting grantees to state their plans for evaluating the proposed materials. The fiscal year 1976 higher education announcement for the development of educational materials and methods requests prospective grantees to include in their proposals plans for testing and revising materials. However, it does not provide the grantee with guidance concerning the types of testing and extensiveness of evaluations expected. Our review of the announcements in effect when some of the projects in our study were funded indicated that evaluation was not emphasized at that time.

Vague evaluation plans

Evaluation plans were difficult to locate in some proposals because they were not located under a separate evaluation caption and the accompanying budget request did not always include a line item for evaluation. Also, the statements on planned evaluations were usually vague or limited. For example, the initial proposal for the instructional graduate physics materials project stated that graduate students taking the course would be asked to comment on their problems with the materials and their suggestions would be incorporated in revised editions. The initial proposal for the video tapes for teacher education project stated that the tapes would be tried out by curriculum study projects (those projects which produced the materials whose classroom use was video taped) and at tryout centers (schools cooperating with the video tape project). Neither of these projects (1) identified in their proposals how the testing would be done and the results evaluated nor (2) requested evaluation funds as a separate line item in the budget that accompanied the proposal.

Evaluation apparently was a low priority

Some project officials said that they did not receive sufficient funding to perform adequate evaluations. For the elementary mathematics and science teaching project, a network of trial centers was established for evaluating the materials. According to a project official, the number of trial centers was reduced from 16 in the 1964-65 school year to 10 in the 1965-66 school year and later further reduced because of limited Foundation funding. Also, project officials said that necessary revisions to the materials suggested by the test results were not always made because of curriculum production pressures and funding.

Project officials for the instructional elementary mathematics project said that their evaluation plan was not fully implemented because of time constraints to complete project development and a shortage of funds. They initially intended to use standard achievement tests and devise other tests to measure student achievement. However, only subjective testing--based upon teachers', consultants', and the project staff's opinions of the materials--was performed.

The relative low priority the Foundation gave evaluation is further evidenced by its selection of activities to absorb budget deferrals. For example, the Foundation's fiscal year 1975 budget had allocated $1 million for the problem assessment program which had recently formed to deal with problem areas including evaluation. Responding to a decision by the President to restrain fiscal year 1975 budget outlays, the Foundation decided that of the proposed $15 million of its budget outlays to be deferred to fiscal year 1976, $1 million would be from its problem assessment program--the total amount of that program's fiscal year 1975 budget.

Foundation's awareness of materials' evaluations

The Foundation's program managers were not always familiar with the details of the evaluations performed or the actual test results obtained. For example, the program manager for one curriculum project was generally aware of the testing activities performed but was not aware of the details and test results achieved. He knew that a measurable objective had been established but was not certain how well the project achieved this objective. He said that the Foundation did not receive all the final test results for this project.

Another project was authorized a no-cost extension to use part of the remaining project funds to evaluate the classroom performance of preservice teachers using the teaching methods developed through the project. The Foundation's program manager said he was not certain of the specific evaluation to be performed, except that the evaluation was to show if the teaching techniques used in the project's teaching methods course were more effective in helping children learn science. However, he stated that the planned testing was to be of student teachers' performance and not the elementary students exposed to the new teaching methods course. Also, he was not sure if objective test measures were planned but believed the testing was more subjective based mainly on observing classroom teaching techniques.

Although the no-cost extension was ongoing about 1-1/2 years at the time of our fieldwork, the program manager was not sure whether the evaluation had been completed or what the test results showed. He believed the Foundation had not received any formal feedback on the test results.

In assessing and monitoring evaluation plans proposed by developers and others, the Foundation might have to develop additional internal expertise. When a Foundation program manager was asked about the adequacy of materials' evaluations for a project under his responsibility, he stated that he was not an authority on evaluations and questioning test results was not part of his duties. Another Foundation program manager said that the Foundation staff input on evaluation is to request evaluation by the project staff and to direct the project staff to specialists, since the Foundation staff do not consider themselves evaluation experts.

We do not believe that program managers should be evaluation experts; however, there should be a centralized organization in the science education directorate to provide expertise and assistance. The directorate's recently formed Office of Program Integration (whose responsibilities include evaluating the Foundation's science education programs) could possibly provide such assistance to program managers in reviewing individual project evaluation plans and monitoring the implementation of the plans.

INEFFECTIVE EVALUATION

Developers of education materials should (1) know what their proposed products are intended to achieve and (2) state the products' objectives in measurable terms. This aids Foundation management in deciding whether to support a project and to better gage project progress by assessing actual results against expected performance. Well-defined objectives are also essential for designing adequate testing procedures to effectively evaluate the extent to which the product meets the stated objectives.

The evaluation design of the final product should provide for testing procedures that include some form of objective testing, such as formal tests that are designed to measure the extent to which stated objectives have been accomplished, and provide for reporting final test results. The evaluation design should also consider followup or longitudinal studies after the materials are distributed to determine their long term effect on students.

Imprecise project objectives

The 10 projects we reviewed met their broad objective of producing educational materials and/or approaches. However, eight projects' objectives were not stated in measurable terms; that is, performance criteria or product expectations were vague or nonexistent.

According to a number of authors of studies or articles on curriculum evaluation, stating objectives in vague terms is one of the major problems. In one article, the authors stated: 1/

> "* * * educational objectives as they are usually expressed by writers and teachers suffer from four

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1/Domain--Referenced Curriculum Evaluation: A Technical Handbook And A Case Study From The Minnemast Project, CSE Monograph Series in Evaluation, Volume I, University of California, Los Angeles, 1973.

> deficiencies: (1) they often do not specify the actual behaviors that the student should exhibit but refer instead to understandings or appreciations of subject-matter content * * *; (2) they often specify what the teacher will do rather than what the student will learn * * *; (3) they are often ambiguous * * *; (4) they are often incomplete * * *.
>
> "These deficiencies arise in part because curriculum writers often do not know in detail what their objectives really are. Instead of beginning with a list of objectives and designing educational experiences to accomplish them, writers and teachers frequently work in the other direction, beginning with ideas for what they feel should be valuable educational experiences and deducing the objectives from the experiences. Thus, important objectives may be implied by the materials a writer develops, but he may be unable to state them clearly or may actually be unaware of their existence. * * *"

Examples of some of these problems, which were prevalent in the projects we reviewed, follow.

The objective of the instructional graduate physics materials project was to prepare a comprehensive set of composite instructional materials for the physics of wood and fiber components. The project's objective was concerned with subject-matter content and not with the behaviors or skills that the student should learn using the materials.

The objective of the video tapes for teacher education project was to provide a central resource for inservice and preservice teachers of mathematics, science, and social science. The project's objective was what the teachers would do and not what the students would learn. A peer reviewer evaluating the merit of the proposed request stated that,

> "* * * The proposal simply states what is planned, mostly in quantitative terms, there is no provision for research or any evaluation of the effectiveness of the procedure. * * * There is no mention in the whole proposal of how they are going to determine the effectiveness of these films for changing first, the teachers and then the crucial question: how well this kind of training will improve student learning."

According to a project official, no attempt was made to evaluate educational effectiveness because she believed the objective was more the production of professionally accepted and good quality video tapes.

Generally, we believe the objectives of each of the eight projects having vague, immeasurable objectives were incomplete. For example, the life science technician training project was to develop teaching modules--self-contained instructional units--for educating and training life science technicians. While such an objective is fine for an overall statement of what the project is about, more specific, measurable objectives are needed (1) to determine what the project expects to accomplish and (2) to measure its sucess in meeting the specific objectives.

The objective could have considered

--what percent of the students should perform the desired task by using the instructional units to consider a unit acceptable and the means to measure the students' performance and

--comparative testing to demonstrate whether the modular approach was more effective than traditional methods (generally teachers lecturing to students)

Adequacy of evaluation designs and testing conducted

All the projects we reviewed had proposed some form of evaluation. However, most evaluation designs were not adequate for Foundation officials and others to assess the effectiveness of the developed materials. Generally, the testing was subjectively based upon students', teachers', or other reviewers' opinions of the materials and usually did not include objective performance testing. We noted other problems for the projects that we examined the test results, such as incomplete data which resulted in some questionable test results.

Subjective testing

Generally, the materials developed through 6 of the 10 projects were evaluated using subjective measures, such as obtaining students' and teachers' opinions by interviews or questionnaires. Subjective testing is a valuable testing mechanism for obtaining potential users' and others' general impression of the materials and their opinions as to the materials' scientific and technical accuracy. However, we do not believe this type of testing in itself is sufficient for determining the effectiveness of educational products in improving science education. It produces results based on personal beliefs or interpretations. One evaluator may interpret responses differently than another and opinion surveys may show how reviewers feel about the materials but not whether the students and/or teachers are learning or understanding the materials.

The extensiveness of subjective testing varied among the six projects. For example, the evaluation procedures for the instructional graduate physics materials project consisted of the project director asking his peers and graduate students taking the course to comment on the materials, with such comments serving as the basis for revisions. In the life science technician training project more extensive subjective testing was performed of the teaching modules developed. The modules were reviewed by the project staff and consultants to make them scientifically and technically accurate. Also, questionnaires were used to obtain student and teacher opinions of the modules. At the time of our fieldwork, 9 modules had been tested at 41 test sites (4 or 5 test sites per module and some test sites testing more than one module), which involved about 60 to 160 students per module and about 4 to 6 teachers per module.

The questionnaire data had been obtained and tabulated, at the time of our field work, for 9 of the first 51 modules marketed. For four of the nine modules, teacher responses were not obtained. Although the students' and teachers' responses were generally favorable, they also raised a number of questions which should have been followed up by the project staff to see if the modules needed revisions before they were distributed. Some examples follow.

For the 5 modules from which teacher opinions were obtained, 21 responses were received, of which eight did not indicate they would definitely purchase the modules in their present forms.

One question on the student questionnaire was designed to determine whether prerequisite skills other than those already identified were needed to perform the task the module was to teach (such as how to weigh less than 1 gram). Student responses indicating that other prerequisite skills were necessary ranged from 30 to 51 percent for the nine modules.

Another question on the student questionnaire was to enable the project staff to determine how well the students knew how to perform the technician tasks before studying the modules. However, for two of the nine modules this question was not included. For the seven modules in which the question was included, student responses stating that they completely knew how to do the technician tasks before studying the module ranged from 14 to 49 percent. We noted, however, that these students were not excluded from the sample. This could have biased the results of another question asking whether the student could complete the technician task after studying the module. The test results for the nine modules (without adjustment for students who stated they completely knew how to do the task before studying the module) ranged from 7 to 25 percent disagreeing that they could do the task as a result of studying the modules.

Objective testing

To demonstrate whether students and/or teachers are achieving the educational objectives of the materials being developed, objective performance testing is necessary. The Foundation supported extensive evaluations for the materials development by the remaining four projects. The projects' materials were evaluated over several years using subjective test measures and comprehensive objective testing involving a number of schools and thousands of students. The objective measures included tests of content and concept learning; pre- and post-tests containing multiple choice and open-ended items on information, concepts, and attitudes; and comparative testing using standardized tests designed to cover the projects' objectives.

For two of the projects, we examined the testing design and results and found problems which we believe make the results for some of the testing questionable. One example follows.

The Foundation provided over $2.3 million to develop an instructional elementary science curriculum. Most of the educational exercises developed through this project were evaluated over a 5-year period (school years 1963-64 to 1967-68). For example, in the 1965-66 school year, over 700 students were tested each month. Materials for each grade level were tried out for at least 3 school years and generally revised based on the testing experience. Each exercise had desired objectives that students were to achieve. To determine whether students were achieving the objectives, students were randomly selected by the project staff and teachers observed the students' actions or responses to a question. The teachers marked a checklist as to whether an acceptable response was received. Also, teachers provided feedback by recording their opinions, observations, and suggestions for each exercise.

The project staff identified a sequence at each grade level in which the exercises should be taught. There were 22 to 26 exercises at each grade level. The project staff believed the students had to learn the objectives of earlier exercises in sequence to successfully achieve later exercises. Because the exercises were taught in sequence, the students with the necessary prior years experience should perform better than students without this experience. Test results proved this to be true. However, due to the changing composition of the participating school systems and the high turnover of students, the number of fully experienced students tested was limited to no more than four students per exercise in the last year in which objective test results were compiled for grades 4, 5, and 6. According to the project evaluator, the limited number of fully experienced students resulted in highly unreliable test results concerning the expected performance of fully experienced students completing the exercises.

The project staff estimated the annual student attrition rate to be 10 percent due to student transfers or other reasons. However, data was available from the Bureau of Census (as early as 1948) on population mobility by age groups, which at the time the project was funded indicated the annual attrition rate to be about 18 percent for the elementary school age group. Actual experience during testing of the materials indicated that the annual rate was closer to 20 percent.

The changing composition of school systems for testing the students also limited the number of experienced students. In the early years of testing there were as many as 14 school systems; in the final test year there were 11. The composition of the school systems varied over the 5-year testing period with some being added and others dropping out. As a result, only eight participated in the testing for the entire 5-year period. This, coupled with the underestimated annual rate of student attrition, resulted in the few fully experienced students included in the later test years.

Limited comparability testing was also performed. In test year 1963-64 students in kindergarten through 3rd grade, who had no prior exposure to the project materials and were being taught traditional science courses, were tested with the project materials against fellow students who had been exposed to the project in the testing program. The objective was to determine whether students who were exposed to the project materials had already acquired the skills the materials were to teach before exposure to the materials. The reported results indicated that children exposed to the project materials acquired the desired skills not present in children who had not been exposed to the materials.

The test results showed, in effect, that students using project materials learned those materials better than students not using them. Although such data is useful, the comparability testing could have been more meaningful if the project students were also tested on other materials or with standardized tests. Such testing would have provided data on learning gains made by the project students compared to gains made by students using other elementary science materials.

Evaluation reporting

To be useful in decisionmaking, evaluation results (complete with supportable claims) should be available to potential users. Six of the projects did not prepare evaluation reports. Consequently, interested potential users could not be aware of the extent that the materials were evaluated or of the test results.

Four projects prepared evaluation reports; however, none of the reports were listed on the distributors' price lists as part of the package of materials for sale. Two of the reports were basically internal project reports, one was available from the material's developer, and the other was available from the developer and the distributor of the materials. Of the four evaluation reports, three were incomplete because they either did not report on the total or final test results or other factors which could have affected test results. Also, three of the four projects that prepared evaluation reports obtained a publisher for their educational materials. Some promotional claims for their materials were not substantiated by the evaluation reports. Examples follow.

Final test results not reported for all materials

The testing of the instructional elementary science curriculum project materials took place over 5 years as the materials were being developed. Two evaluation reports were published that reported the results of the initial 3 years of testing for the kindergarten through grade 6 materials. Materials for grades 4 through 6 were further evaluated in the 4th and 5th test years but no evaluation report was published.

The project evaluator said that in the later test years substantial revisions were made to some exercises and their effects on students' performance were not always evaluated. An analysis of the test results showed that students performed worse in some exercises after revisions were made. At least a summary evaluation report describing all testing of the final materials and the results should have been published for potential users.

Incomplete test results not disclosed

In evaluating the materials of the studying the environment project, data was collected primarily through questionnaires sent to teachers asking them questions on changes in student and teacher attitude and performance. Of 90 teachers included in the pretesting, 38 responded.

The evaluation report states that 38 responses were received but does not disclose whether a followup was attempted to obtain test data from nonrespondents, which is necessary because of the unknown affect of the nonrespondents. A project official said that no followup was performed, which we believe renders the test results questionable.

Product claims not substantiated

For the instructional elementary science curriculum project a measurable targeted objective was established. The objective was that, as a minimum, 90 percent of the children acquire at least 90 percent of the desired skills for each exercise. Project materials were published by grade level as development and testing was completed. The kindergarten through grade 3 materials were marketed in 1967 and the promotional brochure for these grade level exercises stated: "In the testing phase of the program, involving more than 7000 children in the fourteen tryout centers [school systems] essentially 90% of the children achieved 90% of the objectives."

Promotional material available after materials for all grade levels (kindergarten through grade 6) were available noted the curriculum validation as "unprecedented." The following claim was made: "* * * Few others could point to such a high degree of success--90% of children tested attaining 90% of the program objectives.* * *" Our review of the test results showed these claims were inaccurate.

The project's evaluation reports contained no summary statement on the total number of exercises in which the 90/90 level was achieved. To test the product claim, we charted the test results as stated in the evaluation reports using the most experienced students (example: students with 3 years prior experience in the program--kindergarten through grade 2--would be considered in analyzing test results of grade 3 exercises). This approach was agreed to by project officials because such students should perform better. Our analysis showed that these students generally did perform better than the less experienced students, but for a number of the exercises even they did not achieve the 90/90 level.

In the published edition for the kindergarten through grade 3 there were 93 exercises. In charting the final test results, we noted that 5 of the 93 exercises were not tested as to the 90/90 targeted objective in the last year in which the exercises were tested. Considering the 88 exercises for which objective test results were obtained, we found that for 24 exercises students did not achieve the 90/90 level. Also, for 12 of these 24 exercises students did not even achieve a 90/80 level.

The complete published edition of the exercises (kindergarten through 6th grade) totaled 162 exercises. We noted that for 39 of these, students were either not tested as to the 90/90 targeted objective or objective test results were not compiled in the last year in which these exercises were tested. Sixth grade materials accounted for 23 of the 39 exercises. According to project officials, new exercises were, in effect, created each year because of revisions after the prior test year. The project evaluator said this was especially true in the later test years when revisions were more substantial. Considering the 123 remaining exercises for which test results could be used, for 36 exercises students did not achieve the 90/90 level.

Another example of an unsupported product claim was for the studying the environment project. The evaluation included test results from early elementary to junior high grade levels. However, the results for all grades were combined on the project staff's assumption that it was not necessary to factor out by grades because the results would remain the same. Thus, the publisher's promotional materials noted that the product has applications to all grade levels from kindergarten to the college level, even though all grade levels were not tested, nor was the assumption that the results would apply equally to all grades demonstrated.

NEED FOR INDEPENDENT EVALUATIONS OF FINAL MATERIALS

Evaluations during development of the 10 projects' materials were conducted through the project staff. The Foundation directly funded a separate evaluation of the final project materials for only 1 of the 10 projects, which was a followup study. Foundation support of independent evaluations of final versions of materials would help eliminate questions about objectivity resulting from the identity or close liaison of developer and evaluator, which is especially important when some developers place little emphasis on formal testing of final materials. For example, when discussing the deficiencies in testing the life science technician training materials (see p. 11), the project director stated that his staff and consultants had reviewed the project's materials (modules) for accuracy and quality and, therefore, no formal evaluation was needed to determine whether the students would be able to perform the desired tasks from using the modules.

Evaluating educational materials is complex and developers might not have the expertise to design and conduct adequate evaluations. Also, developers are primarily occupied with producing the materials and might not have time to devote sufficient attention to formal evaluation. We believe that adequate evaluation is an important element in developing materials. Further we believe that independent evaluators can provide this important element.

NEED FOR FOLLOWUP EVALUATIONS

Followup or longitudinal evaluation is the testing that determines what effects have resulted after long term use of the materials by school systems. The Foundation funded a followup evaluation for one of the projects we reviewed--the social studies elementary course--which is scheduled for completion in January 1977.

Testing educational materials before their distribution might show their effectiveness in training students and teachers during development of the materials, when factors which could influence their effectiveness are given special attention and might not become significant until after the project is complete and the materials distributed for use. These factors include the amount of time required to train teachers and students to use the materials, cost of the materials, and consultants available to assist teachers if and when problems arise.

During our review we spoke with users of some of the materials, such as school officials and teachers, and were given examples of how these factors could influence their use and effectiveness. For example, for some of the projects, schools were not using the complete curriculum as developed because of the cost and/or the time required to teach it. The effect that these and other factors have on the effectiveness of the materials in training students and teachers should be determined by a followup evaluation. (See p. 39 for additional comment on the need for followup studies).

MORATORIUM ON IMPLEMENTATION PROJECTS

Because the Foundation's implementation activities could be subsidizing the marketing or promotion of education materials and education materials developed with Foundation support could have a competitive advantage over materials developed by the private sector, the Congress did not provide funds for the Foundation's precollege science education implementation activities for fiscal year 1976. The House Appropriations Committee's report (No. 94-313) stated:

> "* * * Since the Foundation is currently developing a number of courses in * * * [the broad behavioral science category] and is in the process of implementing others which have never been reviewed by the Committee in terms of their national need, the Committee has included no funds for the implementation of courses in 1976. This will give the Foundation time to prepare the necessary data and to fully inform the Congress and the public of its intentions and the basis on which it has determined the pressing national need for such course material. It will also give the Congress time to fully evaluate the impact of federal involvement in this field and arrive at effective public policy guidelines for the development and implementation of such materials. This means that no funds are appropriated for implementing courses that were budgeted in the line items for Instructional Improvement Implementation in the elementary and secondary school programs."

The Senate Appropriations Committee concurred with the House action.

We believe the problems with evaluating Foundation-supported educational materials show that the Foundation needs to emphasize more evaluation of the materials. Evaluations are needed to demonstrate whether the materials will improve science education before the Foundation supports the materials' dissemination through implementation projects. The materials developed by six of the seven precollege projects we reviewed had received Foundation implementation support totaling over $9 million. (See app. I.)

The Foundation has taken steps to more formally establish the science education needs of schools and has reassessed its ongoing precollege curriculum projects. (See p. 42.)

As of September 29, 1976, the Foundation's authorization bill for fiscal year 1977 (H.R. 12566) had passed both the Senate and the House. The Foundation did not request funding for any curriculum implementation activity, as in prior years, that would assist teachers and administrators in adopting or using Foundation-funded on non-Foundation-funded curriculums. However, the bill authorizes $69.4 million for science education programs, of which $800,000 is for instructional improvement implementation. The Foundation intends to use funds made available for this purpose for information and dissemination activities concerning new materials, practices, and teaching technologies.

CONCLUSIONS

The Foundation needs to emphasize more evaluation of education materials that it supports. Most of the projects' materials evaluations did not sufficiently demonstrate that students will acquire the desired educational outcomes. Even in some cases where evaluations were more thorough, there were flaws in their designs which rendered certain results questionable. Also, the final versions of some of the educational materials to be distributed were not tested. Thus, as these educational materials are purchased by school systems, students are subjected to materials whose effectiveness has not been adequately demonstrated.

A policy statement from top management is necessary to commit the Foundation to emphasizing more evaluation of educational materials. The policy should be implemented by developing formal evaluation criteria to aid Foundation staff and grantees. If implementation activities are resumed, the evaluation criteria should be applied to all materials (those developed with Foundation support and others) being considered for implementation support.

The evaluation criteria should list different types of testing techniques for grantees to consider in testing their proposed materials. For example, it should consider obtaining opinions from potential users, such as teachers and students, and objective performance testing to demonstrate students' and/or teachers' achievement of desired objectives, such as comparability testing with pre- and post-test devised to measure accomplishment of projects' objectives. In considering test measures, we believe both subjective and objective measures are valuable; however, subjective measures alone are not sufficient to demonstrate the impact of the educational materials on students. The evaluation criteria should also request grantees to state the extensiveness of their planned evaluations, such as the number of students and teachers to be tested.

Formal independent evaluations and followup or longitudinal evaluations should also be part of the evaluation criteria. Ideally, independent sources should evaluate the final materials and followup studies should always be made to determine the materials' long-range impact on students. However, it might not be cost-effective for the Foundation to support such evaluations in all cases and guidelines will be needed.

A report that adequately discloses to school officials and other users the evaluation plan and testing results is an essential element to disclose the positive and negative points of the materials and the degree that the materials have been tested in support of educational claims. Only 4 of the 10 projects provided an evaluation report and none of the reports were listed on the distributors' price lists as part of materials for sale. Three of the reports were incomplete and did not support some promotional claims.

The Foundation's specific requirements for evaluating educational materials developed through individual projects, which should be based on the previously mentioned evaluation criteria, should be communicated to prospective grantees through program announcements or other media requesting proposals. In the past, program announcements were either silent on evaluation or used very general terms which generally left evaluation planning to the prospective grantees. For the projects we reviewed, this usually resulted in vague evaluation plans with the general statements on evaluation sometimes scattered throughout the proposal and requested funding for evaluation not always disclosed in the budget.

RECOMMENDATIONS

We recommend that the Director of the Foundation:

- --Issue a policy statement committing the Foundation to the administrative and financial support of evaluating education materials and requiring that Foundation officials become more directly involved in planning and monitoring evaluation activities.
- --Develop criteria for evaluating educational materials to aid Foundation officials, materials' developers, and evaluators. The criteria should require that consideration be given to the use of subjective and objective test measures, extensiveness of evaluations, evaluations of final versions of education materials, followup studies, and independent evaluators.
- --Require through announcements for proposals to develop education materials that the proposals contain a separate evaluation plan that states materials' objectives in measurable terms and provides an evaluation design to demonstrate whether the objectives have been accomplished and that the accompanying budget contain a line item showing the cost of evaluation.
- --Require a formal evaluation report for all materials developed with Foundation support. The report should be reviewed by Foundation officials for accuracy and completeness and should be available through the distributor as part of the materials' package.
- --Insure that the above recommendations are applied, as feasible, to ongoing projects supporting the development of science education materials as well as to all future projects.

We recommend also that if implementation support activities are resumed, including the information dissemination activities, the evaluation designs and test results for the materials considered for implementation support be reviewed by the Foundation using the evaluation criteria which we are recommending be developed.

AGENCY COMMENTS AND OUR EVALUATION

By a letter dated August 19, 1976, the Foundation commented on our recommendations. (See app. II.) The Acting Assistant Director for Science Education later provided oral comments to clarify the Foundation's August 19, 1976, response concerning the need for an evaluation policy statement and a formal evaluation report for all materials developed with Foundation support. The Foundation agreed with the substance of our recommendations and planned corrective actions. Although the Foundation's planned improvements for evaluating education materials are largely in the "thinking stage," it appears that, in some cases, the intended improvements may not be sufficient to correct the identified problems.

We recommended that an evaluation policy statement was needed to commit the Foundation to more emphasis on evaluating educational materials it supports. In response, the Foundation referred to a June 1975 National Science Board policy statement on the Foundation's implementation of precollege science curriculums. Regarding evaluation the policy states:

> "Prior to undertaking full-scale dissemination and assistance activities for NSF-[Foundation] developed materials, NSF should undertake a careful review to ensure that the proposed subject matter fits within reasonable limits or norms with respect to educational value and that the scientific content is accurate. Recognizing the broad base of concern with elementary and secondary education, the Foundation should provide opportunities for input in this review by representatives of the scientific, educational, child development, commercial publishing, and informed public communities."

The Foundation stated that:

--The policy statement was a first step toward committing the Foundation to a policy requiring independent evaluation of curriculum materials.

--It plans to extend the policy, as appropriate, to cover all projects involving the production of curriculum materials for distribution.

--The extension of the policy clearly implies that the Foundation will be more directly involved in planning and monitoring evaluation activities.

The Acting Assistant Director for Science Education said that the Foundation intends to place more emphasis on evaluating educational materials without issuing a revised National Science Board policy statement that explicitly provides for the evaluation committment, as suggested by our recommendation. However, he might issue an internal circular to reflect the revision.

Management should clearly communicate its policies to insure uniform and appropriate action. The purpose of our recommendation was to have the Foundation establish a policy to advise the Congress, Foundation officials, and prospective applicants seeking Foundation support to develop education materials, that the Foundation intends to support evaluation and become more involved in evaluation throughout a project. The Foundation's interpretation of the board's policy might be sufficient for its purposes, but other interested parties also need to be advised of the broader application of the policy statement to avoid misunderstanding.

For example, the National Science Board's policy statement was issued to cover implementing precollege science curriculums. The Foundation said that it plans no further implementation activities. The policy, therefore, appears to be defunct. The policy calls for a "careful review" of the materials before full-scale dissemination. What is meant by a careful review is not clear. In December 1975 the Foundation, in response to the board's evaluation policy statement, obtained prospective users' and others' opinions of its ongoing precollege curriculum projects. As discussed on pages 10 and 45, opinions are useful, but are not a substitute for formal evaluation of the final materials that demonstrate whether students will acquire the desired educational outcomes.

This report contains recommendations that provide for formal evaluation of educational materials (ch. 2) and periodic review during their development by users and others (ch. 3). The Foundation has agreed to these recommendations so that, notwithstanding the limitations of the board's policy statement, the Foundation's planned evaluation practices should help provide emphasis on evaluation. However, it will take time for this emphasis to develop through experience. Therefore, misunderstandings of the evaluation policy by the Congress, prospective grantees, users, and other interested parties outside the Foundation might occur because the Foundation's planned evaluation practices are not explicitly provided for in the National Science Board's policy statement. The Foundation should issue an explicit policy statement as we suggested.

The board's policy statement, although receiving some internal and external distribution, was not communicated through the Foundation's established means of informing the educational and scientific communities of important policy changes. This means involves issuing an "Important Notice to Presidents of Universities and Colleges and Heads of other NSF Grantee Organizations." If the Foundation issues a new policy statement, as we suggested, it should be distributed to the educational and scientific communities through the notice of important policy changes.

The Foundation agreed with our recommendation that it should develop criteria for evaluating educational materials. It commented that the criteria would recognize that specific evaluation plans will vary, depending on variables, such as a project's type, cost, and purpose. Such variables should be considered. Also, the Foundation agreed that requirements for evaluation plans would be included in program announcements and that evaluation plans, as well as line item budgets showing evaluation costs, would be required.

We also recommended that the requirements for evaluation plans provide for stating materials' objectives in measurable terms. The Foundation did not specifically comment on stating materials' objectives in measurable terms, but stated that it intends to assure that materials' purposes are clear and explicit and that project objectives are more narrowly and precisely stated. This response leaves uncertain the emphasis that the Foundation will place on requiring materials' objectives to be stated in measurable terms.

Stating objectives of educational materials in measurable terms provides criteria for determining whether the desired educational objectives have been achieved. The Foundation's intention to insure that materials purposes are clear and explicit could result in little change to the current situation. For example, the objectives for the 10 projects we reviewed were clear in that educational materials and/or approaches were to be developed. However, as discussed in this chapter the materials' expected achievements in terms of measurable student accomplishments were usually vague or nonexistent.

Clear and explicit objectives are desirable for any Foundation-supported project, but the Foundation should also work toward having its grantees state the objectives of educational materials in measurable terms. Further, it should document its records on a case-by-case basis to justify its rationale if it supports projects that do not have measurable objectives.

The Foundation, in responding to our recommendation concerning evaluation reports for educational materials, placed a number of qualifiers on its intended actions; thus, its intended actions might not sufficiently correct the problems.

We recommended that the Foundation require a formal evaluation report for all materials developed with its support. The Acting Assistant Director for Science Education said that detailed formal evaluation may not be cost-effective or appropriate for every project. We recognize that the extensiveness of evaluating education materials will vary among projects, and that evaluation costs, materials' development cost, expected use, and other variables related to cost effectiveness should be considered. However, educational materials distributed for use in the Nation's school systems should be evaluated. Further, regardless of the extensiveness of evaluating the materials, a report should be prepared and made available to interested potential users. The potential user can judge the merits of the evaluation; however, a report is necessary to provide that opportunity.

We also recommended that the Foundation review the evaluation report for accuracy and completeness. The Foundation stated that project evaluation efforts would be monitored and reports reviewed for clarity, consistency, and reproducibility. However, it commented that statements by it that endorse or guarantee the evaluation report's validity are not desirable because of inherent uncertainty, given the state-of-the-art of evaluation.

We do not expect the Foundation to formally certify the evaluation report. It should be satisfied that the evaluation plan meets its evaluation criteria, which is to be developed, and that the evaluation report is an accurate and complete presentation of the plan and test results. To make this determination, the Foundation must sufficiently involve itself in the evaluation planning and conduct so it will be thoroughly familiar with the evaluation design and test results.

We recommended that the evaluation reports be available for interested users, through the distributor, as part of the materials package. The Foundation stated that requiring distribution through commercial publishers was not desirable, as it would appear that the Foundation was promoting materials developed with its support. However, it plans to make the reports available through the Educational Resources Information Center and the National Technical Information Service.

The Foundation's position that distributing the evaluation reports through commercial publishers would give the appearance of Foundation endorsement appears inconsistent with current Foundation practice: Foundation-supported educational materials are distributed through commercial publishers. It apparently does not consider this an endorsement of the materials. Further, it is seemingly assuming that all evaluation reports will be favorable, which might not be so.

Having the evaluation report available from the same source as the education materials is more convenient and timely for the user than having to inquire if evaluation reports are available and then go to additional sources to obtain them. The Foundation should, at least, experiment with requiring evaluation reports to be distributed as part of the materials package.

As we recommended, the Foundation plans, as feasible, to improve the evaluation of science education materials in its ongoing projects supporting the development of science education materials, as well as future projects.

We also recommended that if implementation support activities are resumed, including informational dissemination activities, that the Foundation review the adequacy of the evaluation designs and test results before considering materials for implementation support. The Foundation responded that if funds become available for dissemination of information, the decision to disseminate will take into account evaluation reports, whether funded by the Foundation or not.

We agree that the Foundation should consider the evaluation reports. Also, it should review the evaluation reports using the materials evaluation criteria which we recommended be developed. Sufficient information should be available for the Foundation to judge the adequacy of the evaluation design and the accuracy and completeness of the test results.

MATTER FOR CONSIDERATION BY THE CONGRESS

The Congress has expressed concern over the merit of educational materials developed and otherwise supported with the Foundation's funds. Evaluation is the principal way to determine the education value of the materials. To aid the Congress in assessing the emphasis that the Foundation is placing on evaluation of educational materials, the Foundation could be required to include a line item showing the cost of these activities in its annual budget presentation to the

Congress. The Congress may also wish to consider specifying amounts available for evaluation activities in legislation that authorizes or appropriates funds for the Foundation.

CHAPTER 3

DISTRIBUTION EFFORTS SHOULD BE STRENGTHENED

The National Science Foundation identifies science education needs through informal means, such as conferences, to obtain ideas from experts in the field. The Foundation generally supports developing educational materials through funding unsolicited proposals which are received in response to its announcements of educational needs. Once the materials are developed the Foundation generally relies on commercial publishers to distribute them.

Nearly all of the projects we reviewed had one or more marketing-related problems, such as (1) materials were too costly or too innovative when compared to traditional educational materials or (2) the materials' use was limited to certain grade levels resulting in the need to purchase other materials to have a complete curriculum. As a result, many of the projects have had considerable difficulty obtaining a publisher for their materials. As of March 17, 1976, four projects had obtained a commercial publisher; five projects were either distributing the materials with the aid of their college or university or seeking a commercial publisher; and the remaining project did not develop any specific materials for sale.

The marketing-related problems and the lack of interest by commercial publishers to aid in widespread distribution could reduce the demand for the materials by schools. These problems may be eliminated or lessened if commercial publishers and users, such as teachers and school officials, are contacted by the Foundation when it considers supporting a proposal and during periodic review of a project's progress.

Until recently, the Foundation provided implementation funds for major curriculum and course materials. The implementation program may have helped to reduce the distribution problems associated with the Foundation-supported educational materials. However, beginning in fiscal year 1976 the implementation program was not funded by the Congress, with the result that the materials must "stand on their own."

The Foundation currently has little basis to measure the impact of its supported educational materials in improving science education. The Foundation does not routinely collect data on the distribution of its supported educational materials or conduct followup studies to determine the impact of materials distributed to school systems.

GENERAL DISTRIBUTION POLICIES AND PROCEDURES

The Foundation strives to insure the continuing availability of education materials developed with its support to those sections of the educational and scientific communities that find them useful. The Foundation normally relies on commercial publishers to publish and distribute them. Commercial publishers generally have the capacity to provide for wide distribution for Foundation-supported products.

The Foundation's February 1969 document, "Policies for the Distribution of Publications and Other Materials Developed Under the Science Education Programs of the National Science Foundation," approved by the National Science Board, provides guidance for distributing education materials developed with Foundation funds. This document, which evolved from past Foundation distribution practices, sets forth distribution policies designed to protect (1) the public interest by insuring that educational materials are available to all potential users and (2) private interest by requiring open competition for distribution rights to Foundation-supported materials and no interference with commercial distribution practices. The specific distribution arrangements are proposed to the Foundation by its grantees and contractors and approved by the Foundation.

PROBLEMS IN DISTRIBUTING EDUCATIONAL MATERIALS

The Foundation has no formal procedures for assessing educational needs. Its officials identify broad needs through informal means--such as conferences, meetings of the Advisory Committee for Science Education, ideas from experts in the field, internal expertise--and through proposals received and a variety of projects focused on problem and needs assessment. The broad needs are made known to the education and scientific communities in a number of ways, including professional journal articles, books, project reports, and special announcements and program announcements by the Foundation. Examples of needs outlined in recent announcements are projects to develop models of outside-the-classroom instruction and projects for creating modules, courses, curricula or instructional sequences in newly identified science- or engineering-based problem areas.

Unsolicited proposals are usually received by the Foundation in response to their announcements for developing educational materials. Formal studies showing the need or market demand for the proposed materials are generally not supported by the Foundation. The Foundation relies on its peer review process to verify (1) the need for the materials and (2) potential problems that may inhibit their acceptance and use.

The reviewers selected by the Foundation to evaluate the proposal are usually scientists and educators competent in the scientific discipline covered in the proposal. Reviewers of the 10 projects we examined were primarily college and university educators and researchers. The ultimate users of the precollege educational materials, such as teachers or school administrators, were rarely included as reviewers. For the higher educational materials developed, the college and university reviewers could be considered ultimate users. Publishers' comments were not requested for either the precollege or higher education projects.

We believe the expected users and distributors of the materials could provide valuable comments on the need and acceptability of the proposed materials to aid the Foundation in its decision whether to support the proposed materials' development. A vice president of the Association of American Publishers 1/ advised us during an interview that:

> "The industry is in a better position to relate to a proposed product's 'need' because of its continuing contacts with the educational practitioner and its knowledge of products already available on the market. In fact, the Foundation, as well as the other Federal agencies involved in educational product development, should explore the market needs at all user levels which include parents, students, teachers, school administrators--in addition to the publishers."

1/The Association of American Publishers, according to the vice president, is a confederation of more than 260 member houses and is the major voice of the publishing industry in the United States.

For the projects we reviewed, grantees usually contacted publishers at least 3 years after the initial funding by the Foundation. Commercial publishers found a number of the projects' materials unattractive because of marketing-related problems--the materials were too costly or too innovative compared to traditional educational materials.

Four of the projects--instructional elementary science curriculum, life science technician training, studying the environment, and social studies elementary course--obtained a commercial publisher. However, the latter two projects had considerable difficulty. Three projects--interdisciplinary high school science project, video tapes for teacher education, and elementary mathematics and science teaching project--could not interest a commercial publisher and were distributing the materials through the aid of their college or university.

As of March 17, 1976, two other projects--instructional graduate physics materials and instructional elementary mathematics project--had not obtained a commercial publisher. However, the former project according to the project director, was just completing its materials and attempting to obtain a commercial publisher. The latter project, about 6 years after product development and several unsuccessful attempts to obtain a commercial publisher, was negotiating with a publisher to print and distribute its materials.

The remaining project--coordinated instructional physical science and science teaching program--is a methods course with no specific materials for sale. The project staff held conferences for teachers to observe the new teaching approach and did not seek a commercial publisher.

Examples of the marketing-related problems follow.

Excessive materials' cost

The Association of American Publishers reported that the 1970 and 1973 annual nationwide per student expenditure for all elementary school textbook and supportive material, such as films and slides, was $7.73 and $9.39, respectively. The per student expenditure was obtained by dividing nationwide sales for the materials by total public and private elementary school enrollment. This data indicates the funds available to the elementary schools for all textbook and supportive material, of which science education materials would be one discipline. Elementary science education materials developed by three of the projects were costly even when compared to the nationwide per student annual expenditures for all elementary textbook and supportive material.

Project description	Startup cost per student (note a)	Annual replacement costs of expendable items per student (note a)
Elementary mathematics and science teaching project	b/$18.46	c/$1.65
Social studies elementary course	d/12.50	None
Instructional elementary science curriculum	e/12.92	f/3.04

a/Assumes a class of 30 students without sharing materials.

b/Based on a 1973 price list and includes teacher manuals student materials and kits, property blocks, minnebars, numberline slide rule, and printed aids.

c/Kit refill materials (1973 price).

d/Based on a 1974 price list and includes student booklets, library booklets, games, posters, photomurals, records, filmstrips, and teachers guides. Excludes the cost of film sets which are a vital part of the curriculum. The film sets may be purchased in super 8 mm for $1,750 or 16 mm for $2,350. A super 8 mm projector is offered for $428. Although these materials would be shared, they add considerable startup cost.

e/Based on a 1970 price list and includes expanded process development lab, one set of teacher texts, hierarchy charts, and commentary for teachers.

f/Lab materials (1970 price).

A 1968 Commission on Science Education study provides another indicator of the high cost of education materials developed by the Foundation's grantees. This study compared the cost of eight Foundation-supported science educational materials (which included two of the projects discussed above) to existing science education programs in four school systems at the elementary and junior high school levels. The results showed the Foundation-supported materials were considerably more expensive.

Grade level	Program	Initial cost	Annual cost
		(per class of 30)	
Elementary	Local	$ 40 to $150	$10 to $ 25
	Foundation	180 to 420	75 to 150
Junior high	Local	a/180	Not reported
	Foundation	b/400 to 825	50 to 150

a/Only one local school system reported the cost of introducing a science program in junior high.

b/Materials may be used by more than 1 class of 30 students.

The commission qualified the cost comparisons because at that time most of the Foundation-supported materials were, at least partially, in an experimental stage, which, in accordance with Foundation requirements, would be sold at the cost of printing and mailing. The commission stated that the cost of the Foundation-supported materials to the school systems would rise when the final versions are available through commercial publishers.

The commission concluded, however, that a rough estimate indicated that (1) to adopt a Foundation-supported elementary program would cost at least three times as much as a traditional program and (2) the estimated annual costs would be five or six times greater. The commission reached no conclusions concerning cost comparison of junior high materials because only one school system had reported the cost of introducing a traditional program.

Materials not self-contained

The lack of self-containment--other materials had to be purchased to have a complete curriculum--was a major reason for the lack of commercial publishers' interest for two projects.

For the interdisciplinary high school science project, the materials referred to and required use of portions of other copyrighted Foundation-supported science materials. To have a complete curriculum, a prospective user had to purchase or have available the other curriculum materials. According to a project official, this was a major reason why the materials failed to attract commercial publishers' interest. Thus, the materials were distributed by the project's university duplicating department.

The elementary mathematics and science teaching project also could not obtain a commercial publisher. A major reason was that a complete elementary level curriculum (generally considered kindergarten to sixth grade) was not developed. The project staff initially planned to develop a curriculum for the kindergarten through 9th grade but due to difficulties during development, including internal leadership problems, only a kindergarten through 3rd grade curriculum was developed. As a result, beginning in 4th grade, an elementary school using the curriculum would need to adopt another curriculum that would be compatible with the kindergarten to 3rd grade curriculum.

All of the 20 publishers responding to the announcement that the elementary mathematics and science teaching materials were available for publication indicated no interest in publishing the materials. They cited such reasons as prior commitments and the curriculum was for only kindergarten through 3rd grade. As a result of being unable to obtain a commercial publisher, the project staff contacted its own university press to ask its interest in marketing the curriculum. The university press performed its own marketing study by contacting various publishers and educators familiar with the project to obtain their views. According to the university press director, it was decided not to publish the materials because of various reasons, including (1) the high cost for the materials and equipment and (2) the curriculum terminating at grade 3. One publisher responding to the university press study commented:

> "Our reviewers felt that a complete program from kindergarten through Grade 6 would be essential to marketing any aspect of the program. The costs of completing this program were estimated well into six figures."

As a result of being unable to obtain a publisher, the project's affiliated university printing and graphic arts department printed the curriculum and the project staff distributed the materials.

Materials too innovative

The Foundation encourages developing innovative educational materials to improve science education. However, for five of the projects the innovativeness was one reason preventing them from obtaining a commercial publisher or causing difficulty in obtaining one. The materials were considered innovative for various reasons. For example, schools were not ready for a combined curriculum of mathematics and science or biology, physics and chemistry, which were traditionally taught as separate curriculums. Two examples follow.

The studying the environment project was able to obtain a commercial publisher; however, most publishers contacted did not express an interest. The project's purpose was to develop a curriculum for urban youth, primarily secondary grade levels, with the following objectives:

--Create in students a greater awareness of the nature of environmental processes and resources as related to man.

--Involve the student more directly in the observation, analysis, and interpretation of materials and phenomena in his immediate environment.

--Provide the student with educational experiences that involve decisionmaking and critical thinking to enhance the student's self-image.

The materials primarily consisted of environmental study assignment cards which proposed that students go into the environment and observe or perform different tasks. The assignment cards generally consisted of a title (such as community, evolution, communication, astrology) and actions to be performed. Following are a few examples of the environmental assignment cards produced.

"ASTROLOGY Activity Card

the action: Make a random pattern of dots on a sheet of paper or find one on a sidewalk, wall, ceiling... Find 'constellations' within the pattern. Classify people and other things using your new 'zodiac'.

more: . Compare your new zodiac with the astrological zodiac.
. Use the stars as your random pattern. Find Today's mythological characters in the sky. Create a modern zodiac. * * *"

"COMMUNITY ACTIVITY CARD

the action: Paint a mask on your face! Try wearing it for a whole day.

more:
- Figure out how your mask affected your community.
- Figure out how your community in turn affected you. * * *"

"COMMUNICATE Activity Card

the action: Go outside and find something you think is a public eyesore. Start a campaign to do something about it...and then do it.

more:
- Identify differences between public eyesores and private eyesores.
- Contact political and civil groups for assistance with major projects.
- Record your results.
- Publish your record. * * *"

In the summer of 1973 the project attempted to determine publisher interest by writing to about 100 commercial publishers. Two publishers expressed initial interest to bid on the materials. However, one publisher later declined to bid because of its lack of a nationwide marketing capability. The other publisher was selected in about June 1974 to publish the materials. The reasons why most publishers did not bid on the materials was not documented in the correspondence between the publishers and the project staff; however, the project director believed the main reason for publisher disinterest was that the materials were too innovative. The publisher selected was distributing the materials through its "innovative" division.

According to a project official, the instructional elementary mathematics project was having considerable difficulty obtaining a commercial publisher because publishers felt the market for teacher training materials was limited. He also stated the innovative form of the materials was a problem--subject matter was not designed for a specific grade and it introduced novel ways of doing mathematics. During the period October 1968 through December 1974, the project staff contacted 136 publishers and film distributors; however, only 4 proposals were received. Three of these proposals were rejected by the project staff because one publisher was only interested in distributing part of the project materials and two publishers did not have the financial capability. As of March 17, 1976, the project staff was still negotiating with the fourth publisher--about 6 years after the materials were developed.

Problems with copyright and participant releases

The interdisciplinary high school science project and video tapes for the teacher education project could not obtain a commercial publisher for various reasons. According to project officials these reasons included not obtaining formal releases for copyrighted materials used as part of the high school science project materials and not obtaining written releases from all students and teachers who were filmed during development of the video tape materials. An example follows.

The video tapes for the teacher education project involved the preparation of video tapes of unrehearsed classroom activities for teacher education courses. The video tapes were to show classroom reactions to the different teaching techniques of preservice and inservice teachers. Although the tapes were to be of other Foundation-supported curriculum projects, formal releases for permission to tape classroom activities usually were not obtained from the project directors. Also, the project staff did not always obtain formal releases from students and teachers who were video taped. The student and teacher releases that were obtained were on the basis that the tapes would be used only for educational purposes and distributed on a nonprofit basis.

According to the project director, contact was made with two or three publishers in the early days of the project but the publishers were uninterested, because of potential copyright problems such as the tapes could be easily duplicated. The project director also believed that commercial publishers would be reluctant to publish the materials due to potential legal problems arising from not having obtained formal releases from project directors, students, and teachers. As a result, the video tapes were distributed by the project staff.

Implementation funding

As shown in appendix I, the Foundation provided over $9 million for implementing materials developed for six of the precollege level projects we reviewed. The Foundation's philosophy regarding implementation was that in addition to developing materials, awareness and training activities were necessary to stimulate adoption of the materials. As stated on page 18, the Congress has terminated funding for implementation activities. We do not know the extent that this funding helped to overcome the types of distribution problems previously discussed. It is possible, however, that without funds for implementation, distribution problems will become more formidable barriers for schools in adopting the materials.

IMPACT OF FOUNDATION-SUPPORTED EDUCATION MATERIALS

The Foundation

--does not have a system to assess the impact of the education materials it supports,

--does not routinely collect data on the extent to which schools adopt the materials developed with its support, and

--generally has not supported followup studies once materials are distributed to determine the extent to which schools adopt the materials and the long term impact of the materials on students.

In March 1975, using a 1968-69 Office of Education nationwide listing of elementary schools (which was the latest available), we drew a random sample of schools and sent them a questionnaire to determine the maximum nationwide usage of the Foundation-supported materials developed by the mathematics and science teaching project (materials for kindergarten to grade 3), social studies course project (materials generally for grade 5), and the instructional science curriculum project (materials for kindergarten to grade 6). Each of these projects received considerable Foundation support for developing and implementing the materials.

Project	Foundation funding Total	 Development	 Implementation
	(millions)		
Elementary mathematics and science teaching	$5.7	$5.0	$ .7
Social studies elementary course	7.1	4.8	2.3
Instructional elementary science curriculum	7.2	2.3	4.9

Based on our sample results, we are 95-percent confident that for the schools contained in the Office of Education's listing, the maximum number of elementary schools using the materials nationwide did not exceed 3 percent for the mathematics and science teaching project, 5.4 percent for the social studies course, and 7 percent for the instructional elementary science curriculum. A school using any part of the curriculum materials was counted.

Considering the maximum usage rates, the percent of elementary schools estimated to be using the materials appears small. However, usage data generally should not be used by itself to gage the success or failure of educational materials.

Followup studies needed to better assess materials' impact

Data on the number of schools adopting materials can provide some indication of their usage. However, we believe followup studies are necessary to provide more meaningful data on the materials use, such as the actual use of the materials (adoption of the entire curriculum versus using parts of the curriculum to supplement existing materials) and problems experienced in using the materials. The following limited data on the use of the instructional elementary science curriculum materials illustrates the need for followup studies.

A 1968 evaluation report prepared by the project staff of the instructional elementary science curriculum materials showed the median instructional time necessary to complete the experimental version of the project's materials in the

1965-66 school year. It also showed the median number of exercises completed by three groups of students as categorized by parent education and income levels.

Grade	Median time nationwide spent teaching science (minutes per week)(note a)	Median instructional time (minutes per week) spent for the instructional elementary science curriculum materials	Number of exercises per grade (note b)	Median number of exercises completed (note c)		
				A	M	D
K	44.5	120	24	20	18	15
1	55.7	130	26	23	20	17
2	58.1	170	26	20	17	17
3	73.7	185	26	21	18	16
4	90.7	195	27	19	16	12
5	99.9	220	28	20	18	16
6	109.9	205	27	18	15	11

a/Taken from a 1965 Office of Education study of nationwide science teaching practices for public elementary schools during the 1961-62 school year. This data was added by us to provide a general comparison and was not contained in the project evaluation report.

b/Data is not homogeneous. Grade levels kindergarten to 3 represent the third tryout year of the materials, grades 4 and 5 represent the second tryout year, and grade 6 the first year of tryout.

c/A group-median parent income of $20,000 and median parent education of 2 years of college.
D group-median parent income of $3,500 and median parent education of 8 years.
M group-median parent income and education between those of groups A and D.

The testing results showed that, in many cases, exercises at a grade level were not being completed. The grantee decreased the number of exercises for kindergarten and grades 2 through 6 because of this problem. Consequently these grade levels had two to five fewer exercises in the published edition of the materials. This reduced the total number of exercises from 184 to 162. The above table shows that the median instructional time for these exercises for each grade level in the 1965-66 school year was about twice that of schools as reported by the Office of Education's 1965 study.

In 1970 the Eastern Regional Institute for Education published a study on evaluating the results of using the instructional science curriculum materials for 2 years in 21 pilot schools in New York and Pennsylvania. The pilot schools used the commercial version of the materials for kindergarten through 4th grade during school years 1967-68 and 1968-69. However, the 4th grade materials were studied only during the 1968-69 school year since this is when the commercial version became available.

Mean Time Spent Teaching Science

(minutes per week)

Grade level	Before materials installation	After second installation year	Percentage increase
K	66	85	29
1	81	90	11
2	86	108	26
3	a/	110	-
4	a/	137	-

a/The time was not reported in the study.

Grade level (note a)	Total number of exercises per grade	Mean number of exercises taught per year School year 1967-68	School year 1968-69
K	22	16.0	18.6
1	26	14.8	18.8
2	23	11.3	14.8
3	22	10.1	12.9

a/We excluded the test results for grade 4 because the commercial version was not available to the pilot schools until January 1969.

The above data suggests that even with increases of between 11 and 29 percent in mean time spent teaching science, teachers could not complete all exercises for a grade level. The time spent teaching science in the pilot schools was above the national averages that were published in the 1965 Office of Education study.

In 1971, according to an official of the project's publishing company, the publisher made a survey of 7,000 teachers using the materials because of indications that problems still existed. He stated that about 4,000 responses were received showing the materials were too extensive and required too much time to teach within the period allowed for science. He also stated that the survey showed that none of the 4,000 respondents completed all the exercises for any grade level of the program. For each grade level there were 22 to 26 exercises; the range of completed exercises, according to teacher responses, was from 7 to 23.

In 1974 the publisher offered a revised version of the materials for kindergarten through grade 6 which further reduced the number of total exercises from 162 to 105 because of the instructional time problem.

AGENCY ACTIONS RELATED TO DISTRIBUTION OF PRECOLLEGE MATERIALS

In our report on the precollege social studies course, "Administration of the Science Education Project 'Man: A Course of Study' (MACOS)," we made several recommendations to the Foundation's Director for improving management of precollege education projects, which affect some of the distribution problems discussed in this report.

We recommended that the Foundation experiment with using competitive devices, such as formal requests for proposals, to determine whether a competitive process is feasible and effective for developing education products. The Foundation's Director responded on January 12, 1976, that the Foundation believes formally competitive procedures can be used effectively in the curriculum area and intends to adopt them.

We believe adopting formal competitive procedures for developing precollege curriculums will aid the Foundation in distributing materials because more attention will be devoted to identifying special needs of schools for science education materials. The Foundation has issued three requests for proposals for planning studies concerning needs assessment. A description of the planned studies follows for which, as of March 30, 1976, contractors were being considered.

One study will survey materials' usage in precollege education and will identify science curriculums being used in the classrooms and the classroom practices used in teaching science. The data will probably come from the educational community (such as teachers and administrators) and publishers. A related study will provide for reviewing and evaluating literature concerning practices and procedures for teaching science at the precollege level and also identify and evaluate needs assessment efforts during 1955 through 1975.

A third study will include case studies of school practices for selecting and installing precollege science curriculums and teaching science including inservice teacher education efforts and the effects of science instruction on students.

In our report on MACOS we recommended that the Foundation's Director obtain the publishing industry's views about any effect that the award determination and funding practices of the precollege instructional improvement implementation program might have on the supported educational materials and their publishers. Also, if necessary, the Director should experiment with program revisions to minimize any unfair advantage. The Director's actions to implement this recommendation included reviewing the Foundation's ongoing precollege curriculum projects. The review was also undertaken in response to a congressional directive and concern expressed by the National Science Board that curriculum projects be carefully reviewed before deciding upon dissemination activities.

On March 10, 1976, the Foundation announced the review's results and stated that of the 19 projects included in the review, 8 were mostly completed and pending decisions related primarily to publishing arrangements; 5 would not be continued because their benefits did not seem proportional to their costs; 3 would be continued but the projects' timeframe would be slowed downed and the projects' scope reduced; and 3 would be continued substantially as planned.

The projects were evaluated by panelists chosen primarily from nominees by 40 organizations, which, according to the Foundation, included a broad range of professional and private groups, such as scientists, professional educators, parents, students, and representatives of publishing firms. However, the publishing firms' representatives reviewed only 2 of the 19 projects--those that already had a publisher--because of the Foundation's concern for possible conflicts of interest. We believe the lack of publishers' reviews is a weakness, possibly serious, in the Foundation's study because when the projects are completed the grantees will turn to the publishers to disseminate the materials.

Responding to another recommendation in our report on MACOS, the Foundation's Director stated that more systematic efforts would be made to include users on curriculum proposal review panels and in project evaluations. We believe that such action should be extended to higher education projects. Also, we believe that early contact with publishing firms' representatives is necessary to obtain their opinions of the viability of the materials. Accordingly, such representatives should be considered when selecting reviewers of proposals and projects.

Regarding early contact with the publishing industry, a vice president for the Association of American Publishers said that the publishing industry will review proposals for developing education materials. The official stated that developers usually contact publishers when a curriculum is nearing completion, which is not the best time. Further, publishers can assist developers on such marketing factors as product design and cost.

CONCLUSIONS

The Foundation has taken steps to reassess the direction and worthiness of its precollege level science education activities, as shown by its review of ongoing projects, willingness to include users of education materials as reviewers of proposals and ongoing projects, and beginning studies directed toward education needs assessment. Similar reviews of ongoing projects and planning studies should be considered for higher education projects after study techniques now being applied have proven their value. Consideration should also be given to the future use of the study techniques, such as establishing a system for periodically formally assessing science education needs and periodically evaluating the educational materials being developed under projects funded to meet those needs.

Foundation efforts to improve science education by supporting the development of new, innovative materials have not given adequate consideration to potential distribution problems that might limit acceptance of the materials by school systems. The Foundation needs to give increased attention to specific education products being accepted which it supports during development from the perspective of distributors and users to reduce the likelihood that the materials will "sit on the shelf." More formal education needs assessment should be made and materials users should be included in reviewing proposals and projects. However, both users and distributors need to be involved in the early stages of developing educational materials and their views obtained periodically during the materials' development to insure that the materials will meet the specific needs of users and that barriers to distributing and adopting the materials are adequately considered by the developer.

The Foundation's study of its 19 ongoing curriculum projects included users as project reviewers but only 2 projects were evaluated by representatives of the publishing industry. All planned, completed, and to-be-continued projects should be reviewed by representatives of the publishing industry to minimize potential barriers to distribution. It should be recognized, however, that panelists' opinions are not a substitute for formal evaluation of the final education materials that demonstrate whether the students will acquire the desired educational outcomes. Accordingly, the Foundation should also assure itself that the formal evaluations of the final materials are sufficient to demonstrate that the students will achieve the desired educational outcomes. (See p. 10.)

The Foundation needs to establish a system, possibly through questionnaires, to assess the impact of educational materials it supports. It does not routinely followup to collect data on the extent to which schools adopt the materials developed with Foundation support. Followup studies should be performed to assess the materials actual effect (such as partial use versus adopting the full curriculum) and to determine problems schools have had in adopting the materials. Such studies could provide Foundation management with "lessons learned" for consideration in supporting future projects.

RECOMMENDATIONS

We recommend that the Foundation's Director:

--Develop distribution plan requirements for grantees and contractors requesting funds for developing educational materials that will provide data as part of the proposal package to more specifically demonstrate the materials need and marketability. This data would include identifying existing materials, their strengths and weaknesses, and how the proposed materials will be an improvement; estimating the materials' unit purchase price; and identifying the intended users and possible barriers to adoption of the materials. This data should be reconsidered as the project progresses and formal market surveys also considered for projects receiving large dollar support.

--Establish procedures for selecting reviewers to include publishing representatives to review proposals for developing the education materials and prospective users and publishing representatives to periodically review the materials during development. The views of users and publishers should be obtained for all ongoing as well as future projects.

--Develop a system to provide Foundation management with data to assess the impact of educational materials it supports.

--Determine the worthiness of the precollege education needs assessment upon its completion for possible application to the higher education activities to promote increased competition for awards and more specific determinations of educational needs.

--Consider establishing a system for the periodic formal assessment of science education needs upon completing and evaluating the current planning studies for needs assessment.

AGENCY COMMENTS AND OUR EVALUATION

The Foundation generally agreed with our recommendations and planned actions to implement them.

Regarding distribution plan requirements for grantees and contractors submitting proposals to developing education materials, it agreed with our recommendation and stated that proposers will be expected to identify existing materials, their strengths and weaknesses, intended users, anticipated barriers, etc. The Foundation also stated that as an aid in evaluating proposals, it plans some assessments of educational needs, which would include considerations of claims about gaps in the market and incremental contributions of new materials.

The Foundation agreed with our recommendation concerning the value of obtaining the views of publishers on proposals to develop education materials and to have the publishers and potential users periodically review the materials during development. It intends to obtain the views of users for ongoing and future projects. However, it commented that publisher participation potentially creates a conflict-of-interest problem concerning bidding and competition, but it will investigate ways to obtain publisher input.

The Foundation's response to our recommendation concerning assessing the impact of educational materials it supports does not clearly comply with the intent of the recommendation. It commented that it agreed with the substance of the recommendation as it related to monitoring the state of the science education system and referred to actions that were taken. However, this was not the intent of our recommendation, as monitoring the science education system largely concerns needs assessment activities. In this respect, the Foundation, in commenting on our report, entitled "Administration of the Science Education Project 'Man: A Course of Study' (MACOS)" agreed to the need for formal studies to determine science education needs.

The recommendation in this report concerns the impact of specific education materials developed with Foundation support in improving science education. The Foundation commented that there were technical difficulties, such as discerning incremental impact, and practical problems, such as cost and difficulties in obtaining materials adoption data, in assessing the impact of education materials. However, it plans to work on improving techniques for the analysis of impact and will employ systematically those techniques that seem valid, reliable, and reasonably cost-effective.

Regarding the potential problems cited by the Foundation in assessing the impact of education materials, we believe the Foundation was planning a more sophisticated impact analysis than we intended. It has spent considerable funds to develop educational materials; however, it has no system to obtain data on the usefulness of the materials to the education community in improving science education. The Foundation should, as a minimum, periodically obtain some systematic feedback from users of educational materials which it has supported to obtain (1) the extensiveness of use, (2) the manner in which the materials are used--complete curriculum adoption versus partial use, and (3) problems experienced in using the materials. Such data seemingly can be obtained cost-effectively through the use of questionnaires and statistical sampling techniques, as was obtained for this report. (See p. 38.) The data is needed to provide Foundation management with "lessons learned" for consideration in supporting future projects. The data will also be useful in identifying "problem" materials that should be considered for followup evaluations (see p. 17) to determine the effects of the materials on students after long term use by school systems; recognizing, of course, that followup evaluations should not be limited to known problem materials.

The Foundation agreed with our recommendations to consider the worthiness of precollege needs assessment activities upon their completion for (1) possible application to the Foundation's higher education activities and (2) establishing a system for the periodic formal assessment of science education needs. It commented that systems of higher education are highly differentiated, and that it will, therefore, also consider additional needs assessment approaches than used for precollege.

MATTER FOR CONSIDERATION BY THE CONGRESS

The Congress discontinued funding the Foundation's science education material implementation program for several reasons, including the belief that education materials should be competitive without Federal support. However, the Foundation might identify a need for new education materials for school systems that would not be attractive for distribution by commercial publishers for various reasons, such as being too innovative. Without implementation funding, the developer must bear the burden of distributing such materials and the opportunities for exposing school systems to the materials might be greatly reduced. The Congress may wish to advise the Foundation (1) whether it should support the development of science education materials for which the need has been demonstrated but the materials might not be attractive to commercial publishers and (2) what distribution steps it should take.

CHAPTER 4

NEED FOR MORE ACTIVE AND SYSTEMATIC PROJECT MONITORING

In our report on the social studies elementary course project (MACOS) we cited a number of improvements needed in administering science education projects, such as adequately documenting publisher selection and reviewing subcontracts awarded by the grantee in carrying out the project. The National Science Foundation's Director agreed to implement our recommendations for correcting the administrative problems. In completing our review of the other nine projects we found administrative weaknesses similar to those in the MACOS project and additional project administration problems, including untimely or ineffective action to correct project problems.

We believe that the projects' administration problems resulted from the lack of an active and systematic project monitoring scheme. The Foundation's philosophy toward project monitoring has generally been a "hands off" approach to allow grantees maximum freedom in carrying out a project. Monitoring an individual project has generally been at the Foundation's program manager discretion with no formal guidelines to aid him in using monitoring techniques. The Foundation was previously advised in 1975 by its science curriculum review team 1/ of the need for more systematic monitoring of science education projects. As of April 21, 1976, no action had been taken to provide for systematic monitoring by program managers.

FOUNDATION'S PHILOSOPHY TOWARDS PROJECT MONITORING

According to the Foundation's science curriculum review team, the Foundation's policy on overseeing and evaluating curriculum content for the last 10 years has been that developers of Foundation-supported materials be given the fullest freedom to develop their materials and that their professional judgment should not be unduly influenced by the Foundation. This philosophy has been coupled with a lack of a formal project monitoring system and has resulted generally in a hands off approach to project oversight.

1/Formed in March-April 1975, by the Foundation's Director to make a detailed study of the Foundation's precollege science curriculum activities. Its report was issued in May 1975.

The Foundation's program managers are responsible for monitoring the progress of individual projects. However, there are no formal monitoring guidelines provided to the program managers. As a result, the type of monitoring is determined generally by the program managers and the degree of monitoring varies greatly by project. Monitoring mechanisms generally used by the program managers include grantee progress reports, telephone contacts, site visits, and advisory committees.

PROJECT MONITORING PROBLEMS PREVIOUSLY REPORTED

Our October 14, 1975, report on MACOS contained a number of recommendations to the Foundation's Director, which he agreed with, for improving project monitoring.

Our recommendations were:

--Documentation was needed in project files for (1) evaluation and disposition of peer review comments, (2) reasons for support or nonsupport of implementation proposals, and (3) reasons for selecting a publisher to distribute science education materials.

--Publisher interest in marketing educational materials should be redetermined when conditions which would affect that interest change.

--All contracts and subcontracts for marketing educational materials should be reviewed and approved.

--Controls should be established to insure that the Foundation's acknowledgment of support and disclaimer statement is included on all published science education materials developed with its support.

The Foundation's Director responded to our recommendations and stated that the recently established science education directorate's Action Review Board 1/ would insure adequate documentation for each of the areas we had identified

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1/In September 1975 the board was established within the education directorate to supplement its program officials' review of proposed grants and contracts. The board includes officials of the education directorate and administrative and technical representatives from other Foundation offices, such as the Office of the General Counsel and the Grants and Contracts Office.

in the first recommendation. For the other three recommendations, the Foundation issued an instruction on January 13, 1976, which established guidelines, procedures, and responsibilities for the development, submission, review, and approval of publication plans, publication and distribution contracts, and other agreements relating to Foundation-supported curriculum materials. We believe the Foundation's actions to implement our recommendations are constructive, although experience will be necessary to test their effectiveness.

SYSTEMATIC ACTION NEEDED TO ADEQUATELY IMPROVE PROJECT MONITORING

In reviewing the Foundation's monitoring of the other nine projects, some examples of administrative weaknesses similar to those we found in reviewing the administration of MACOS were found. For example, in one case the Foundation did not receive adequate documentation to support the grantee's selection of a publisher to distribute the educational materials developed with the Foundation's support. Also, regarding publications arrangements, the grantees for two projects had distributed their educational materials through a publisher before the Foundation had approved their publisher's proposed contract. We also noted a number of problems for which the Foundation's action to remedy the situation was either untimely or ineffective. Three examples follow.

Example one

The elementary mathematics and science teaching project had substantial problems over an extended period trying to meet its objectives. The original grant request proposed (1) to develop a curriculum for kindergarten through 9th grade, (2) a development timeframe of 4 years and 7 months, and (3) funding of about $1.7 million. However, the project took almost twice as long to complete, costs were almost three times greater, and materials were produced for six grade levels less than proposed.

The following table illustrates the funding history and time frame of the project.

Curriculum for grades	Foundation support (product development cost only)	Time period covered by awards
K-9	$2,800,990	7/62 thru 6/66
K-6	1,689,000	7/66 thru 9/68
K-3	548,500	12/68 thru 9/70
Total	$5,038,490	

According to the Foundation's program manager, the funds provided during December 1968 through September 1970 were for completing only the kindergarten through grade 3 materials because of the project's continual slippage of final completion dates and the deterioration of its leadership. These problems were cited in various Foundation site visit reports beginning in March 1966. We believe the Foundation should have thoroughly explored the viability of an imcomplete curriculum from the users' and distributors' perspective when considering to provide an additional $548,500 to complete the kindergarten through grade 3 materials. As discussed in chapter 3, the project could not obtain a commercial publisher for several reasons, one being that the curriculum was not complete at the elementary level (did not extend from kindergarten through 6th grade).

Example two

The instruction graduate physics materials project experienced considerable delays in meeting the grant objectives--namely developing a comprehensive set of composite instructional materials dealing with the physics of wood and fiber components. In June 1970 the Foundation awarded $72,555 to support this project for a 3-year period ending on July 31, 1973. In both 1973 and 1974 the project director requested 1-year, no-cost extensions of the grant. In each request the project director said that delays occurred because administrative responsibilities absorbed a larger than expected portion of his time and precluded his placing the originally envisioned amount of effort. The Foundation approved extensions totaling 25 months through August 1975. However, in May 1974 the Foundation awarded $457,800 for a 3-year project which had as its project director the same individual who was project director on the graduate physics project. We question whether the May 1974 grant should have been awarded when the project director had insufficient time to complete the project he was working on at that time.

Example three

The video tapes for the teacher education project experienced low product sales. The peer reviewers of the project's proposal, although generally in favor of the video tape approach for training teachers, raised a number of questions relating to the tapes' potential demand. The Foundation, however, did not contact potential users or commercial distributors to better establish the possible demand for the tapes. It funded the proposal on the basis that the idea had merit.

The project's history shows that before being supported by the Foundation, it was funded for about 3 years by the C.F. Kettering Foundation (June 1964 to July 1967), during which it recorded over 400 hours of classroom activity in mathematics, social studies, English, and elementary education. Only a few edited tapes were produced. When Kettering stated it was terminating funding, the Foundation was contacted for funds to continue the project. The Foundation provided funds for taping classroom teaching situations using materials primarily produced through several Foundation-supported curriculum projects for use in inservice and preservice education of teachers of mathematics, science, and social science. The Foundation did not wait for the users' reaction of the tapes already produced before providing funds for additional tapes, as was suggested by some peer reviewers.

About 1,644 tapes were distributed by the project during calendar years 1968 through 1973 (includes sales of tapes produced through Kettering and Foundation support). This represents an average of 3.6 tapes per master tape produced. Excluding partially edited tapes sold as masters during the first 2 years of the project, 366 master tapes were produced, 1,514 copies of which were sold. This amounts to an average of about 4 tapes sold per master tape produced. Of the 366 edited master tapes produced, 300 sold 6 copies or less of which 103 sold 1 or 2 copies and, 77 failed to sell a single copy. Only 27 edited master tapes sold 12 copies or more, and the 3 best selling tapes sold 82 copies, 32 copies, and 27 copies, respectively.

The project director said that since June 1973, when Foundation support was terminated, the tapes have not been actively promoted. As a result, tapes had been made available on a very limited basis.

Findings of science curriculum review team

The Foundation's special review team formed in 1975 to examine its precollege science curriculum activities reported in May 1975 that monitoring of most projects was broad, vigorous, and responsible but it appeared to lack a systematic approach. The team reported that most contacts with Foundation staff were initiated by grantees, few project progress reports were found, and those on file were normally submitted with a request for renewal of support. The team's report also stated:

> "Major awards have sometimes been deemed necessary to continue efforts on certain projects in order to glean useful materials from earlier disappointing performances. Lack of monitorship has resulted in continued support of some projects where the aims of the Foundation and the grantee have, over time, diverged; where tangential activities have been pursued to the detriment of the goal; and where empire building tendencies on the part of the grantee have become evident."

The review team recommended that (1) the Foundation develop a systematic substantive reporting procedure for science education projects and (2) a phased time and effort plan be required for all grantees and contractors to insure that time-task records are established, progress towards objectives can be clearly assessed, and needs for alteration in the work plan can be assessed. As of April 21, 1976, the Foundation had not taken action to provide for systematic project monitoring by program managers.

CONCLUSIONS

The Foundation has acted constructively to our prior recommendations resulting from our review of the MACOS project to improve certain aspects of project administration--namely documenting the (1) disposition of peer reviewers' comments, (2) basis for either funding or not funding implementation proposals, and (3) basis for publisher selection, including providing more stringent oversight of publisher selection and contracts for distributing science education materials developed with Foundation support. However, our review of additional science education projects and the findings of the Foundation's science curriculum review team, show weaknesses in the Foundation's monitoring of projects which are resulting in untimely and ineffective action to correct project administration problems.

Problems have resulted from the Foundation's hands off approach to project oversight and the lack of formal guidelines to aid program managers in monitoring projects. We concur with the Foundation's science curriculum review team that a systematic approach to project monitoring is needed.

The science education directorate's Action Review Board will provide some assistance by overseeing the grant award process. However, a systematic monitoring scheme that provides for routine oversight is needed to correct the project administration weaknesses. Such a monitoring system must function primarily through the program managers at the Foundation who have the day-to-day responsibility for overseeing the projects. However, the Action Review Board could provide valuable oversight of the program managers' project monitoring activities.

RECOMMENDATIONS

We recommend that the Foundation's Director:

--Issue a policy statement regarding the Foundation's role in monitoring ongoing projects that continues to provide freedom of thought by researchers in conducting their projects but also provides more active involvement by Foundation officials as the project is carried out, especially when problems are identified.

--Establish guidelines to provide more active, systematic monitoring of projects by defining the various monitoring techniques to be used, their frequency of use, and the expected documentation of monitoring activities to be placed in the files.

--Establish monitoring guidelines that consider minimum progress report requirements which include:

1. An expected frequency for grantees to submit reports.
2. A standardized report format that considers reporting progress by previously established project milestones, which should include targets for various stages of material development, evaluation, and dissemination.
3. A provision for the program manager to evaluate project progress and document agreements reached with grantees to resolve problem areas.
4. Circulation of progress reports to higher levels of management within the science education directorate to insure timely and effective action to correct problems.

AGENCY COMMENTS AND OUR EVALUATION

The Foundation agreed with the substance of our recommendations that policies and guidelines should be established to provide for more active and systematic monitoring, and stated that they would be formalized in appropriate circulars. Our recommendations contained a number of suggested management controls to be considered in establishing an active and systematic monitoring system which the Foundation's response did not specifically address. The specific controls to be established can be viewed as management's prerogative. However, the controls suggested should be considered by the Foundation because they would highlight project problems in a timely manner for management's consideration and provide checks to insure effective corrective action. Controls of this nature are needed to correct the project problems identified.

The Foundation commented that recently improved review procedures are intended to assure that "crucial preconditions" for good project monitoring are met, including a clear project plan, a statement of award conditions and Foundation expectations, and a schedule of substantive performance milestones. These planning considerations should be checked for during the proposal review process. However, an active and systematic monitoring system is needed to insure that projects are carried out as planned and that problems are identified and corrected in a timely and effective manner. Further, the new proposal review process and Action Review Board should help to improve project monitoring, but they are not sufficient in themselves. As stated on pages 54 and 55, the Action Review Board can assist by overseeing the grant award process. However, to be effective, a monitoring system must function primarily through the Foundation's program managers who have daily responsibility for overseeing the project, which is provided for in the suggested controls.

The Foundation commented that proper project monitoring raises issues, such as the proper allocation of authority and responsibility for making major project changes. It plans to study the advantages, disadvantages, and requirements of operating in the assistance, solicitation, and procurement modes. The mode of funding should not act as a barrier to good project monitoring. Whether the Foundation funds the development of educational materials through grants or contracts, it has the responsibility and the authority to make changes and terminate projects that are not performing in accordance with agreed-upon work.

CHAPTER 5

SCOPE OF REVIEW

Our review was primarily concerned with evaluating the National Science Foundation's policies and procedures for (1) evaluating and distributing the educational materials that are developed through its science education projects and (2) monitoring these projects. We reviewed the Foundation's application of the policies and procedures to 10 of its science education projects. (See app. I.)

In conducting the review, we:

--Ascertained the statutory authority and functional responsibility of the Foundation for science education activities.

--Examined the project records for the 10 science education projects.

--Interviewed officials of the Foundation, the projects, publishing firms, the Association of American Publishers, teachers and school officials who used materials developed by some of the projects, and personnel who formally evaluated the materials developed.

--Determined the processes for obtaining a distributor and distribution mechanisms used by the project staffs.

--Developed and submitted a questionnaire to a representative randomly selected number of elementary schools throughout the Nation to determine the maximum number of schools using materials developed through three elementary level projects we reviewed.

Our review was conducted at the Foundation in Washington, D.C., and at project offices for the 10 projects reviewed which were located in five States and the District of Columbia.

The scope of review for 1 of the 10 projects--the social studies elementary course--was expanded at the request of the Chairman, House Science and Technology Committee, to consider (1) royalty arrangements and administering royalty income and (2) relationships between the Foundation and the materials' developer and publisher. The results of this effort were included in our October 14, 1975, report to the Chairman on the social studies course titled "Administration of the Science Education Project 'Man: A Course of Study' (MACOS)" (MWD-76-26).

LISTING OF FOUNDATION-SUPPORTED SCIENCE EDUCATION PROJECTS FOR WHICH EVALUATION, DISTRIBUTION, AND MONITORING ACTIVITIES WERE CONSIDERED

Project title	General project description	General types of materials produced	Foundation funding as of June 30, 1975				
			Development		Implementation		
			Amount	Fiscal years	Amount	Fiscal years	Total
			(thousands)		(thousands)		
Precollege projects:							
Instructional elementary science curriculum	Development of an instructional, integrated, and sequential science program of the processes of science for kindergarten through 6th grade covering various fields of science and mathematics.	Instructional booklets for teachers with accompanying kits of materials for use by teachers and students, a self-study manual to assist teachers, learning hierarchy charts, and a guide for instructing teachers preparing to teach the curriculum.	$2,347.3	1963-75	$4,938.0	1966-75	$7,285.3
Social studies elementary course	Development of a social studies course (generally for grade 5) to explore the roots of human social behavior. The course uses studies of selected animal groups and the Netsilik Eskimos--a simple human society.	Films, filmstrips, slides, booklets, records, educational games, Eskimo cards, maps and posters, and a teacher's guide involving books containing such things as background information and suggested lesson plans.	4,857.0	1963-74	2,314.0	1967-75	7,171.0
Elementary mathematics and science teaching project	Development of a coordinated curriculum in mathematics and science for kindergarten through 3rd grade. The course emphasizes the interrelationship between mathematics and science with sequential units that coordinate the teaching of mathematics with the teaching of science.	Coordinated instructional units, kits of materials for each of the units, teacher and student manuals, printed aids for students, teacher handbook, text which provides a new approach to undergraduate mathematics instruction, resource book of materials in science and mathematics history, and booklets explaining and discussing the curriculum.	5,038.5	1963-73	746.0	1967-75	5,784.5
Studying the environment	Development of supplementary materials for kindergarten to college level to help create a classroom environment where students and their teachers can develop a good relationship that helps them to use curriculum materials more effectively. Students are given assignments to go out into the environment, such as the school, neighborhood, and home and explore some element of that environment.	Packets of environmental study assignment cards which instruct students to go out into the environment and observe or perform different tasks, teacher booklets, and descriptive booklets on specific subject areas.	923.4	1970-75	848.0	1971-75	1,771.4
Instructional elementary mathematics project	Development of inservice materials and activities specifically designed for use by local school systems in upgrading the understanding of content and the teaching of mathematics by groups of elementary school teachers. The materials may also be used in preservice training of teachers.	Written lessons for study by teachers, discussion notes and guides for correcting the written lesson, films showing the teaching of mathematics by a variety of teachers, supplementary materials providing mathematical suggestions for the classroom, general information about the course, and 24-hour telephone service for advice, consultation for course leaders, and consultant service to set up the course.	1,525.2	1965-70	120.0	1974-75	1,645.2

Project title	General project description	General types of materials produced	Foundation funding as of June 30, 1975				
			Development		Implementation		
			Amount	Fiscal years	Amount	Fiscal years	Total
			(thousands)		(thousands)		
Precollege projects (continued):							
Video tapes for teacher education	Preparation of video tapes of unrehearsed classroom activities for use in preservice and inservice teacher education courses. The subject fields include science, mathematics, and social sciences and were drawn from all grade levels and many different types of schools and communities.	Over 300 video tapes.	$ 536.2	1968-73	$ -	-	$ 536.2
Interdisciplinary high school science project	Development of a 3-year integrated science course as an alternative to traditional high school biology, chemistry, and physics courses. The course begins with a cross-disciplinary view of the three sciences, develops into the formulation of general principles, and culminates with the application of these principles to more involved problems.	Teacher and student guides with laboratory materials, achievement tests for testing purposes, listing of behavorial objectives, and a program overview.	198.0	1967-72	63.1	1968-69	261.1
Higher education projects:							
Life science technician training	Development of teaching modules--self contained instructional units--for the education and training of life science technicians. Each module is designed to teach students an individual life science technician skill.	Modules consisting of a filmstrip or set of slides, a compact audio cassette, a student guide, and a storage unit.	1,344.4	1971-75	-	-	1,344.4
Coordinated instructional physical science and science teaching program	Development of a course in physics to prepare elementary teachers with the subject matter content and teaching procedures developed for modern elementary science curriculums. The course is designed for both pre- and inservice elementary teachers.	Methods course with no specific materials for sale. Teachers and prospective teachers attend conferences to observe and participate in the new teaching approach.	320.3	1970-75	-	-	320.3
Instructional graduate physics materials	Development of a comprehensive set of composite instructional materials for graduate students dealing with the physics of wood and fiber components.	Textbook consisting of problem sets and laboratory exercises.	72.6	1970-75	-	-	72.6
Total Foundation funding			$17,162.9		$9,029.1		$26,192.0

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE DIRECTOR

August 19, 1976

Mr. Gregory J. Ahart
Director, Human Resources Division
General Accounting Office
Washington, D.C. 20548

Dear Mr. Ahart:

Enclosed are the NSF responses to the GAO recommendations contained in the draft report entitled "National Science Foundation-Supported Science Education Materials: Problems in Evaluation, Distribution and Monitoring." The NSF staff have already held productive discussions with GAO staff on improving the clarity of the report.

I believe that the NSF responses are oriented toward the spirit of the GAO recommendations. The responses build from our new policies on the development of pre-college educational materials as laid out in our budget testimony.

Sincerely yours,

R. C. Atkinson

Richard C. Atkinson
Acting Director

Enclosure

SPECIFIC RESPONSES TO THE RECOMMENDATIONS IN THE GAO DRAFT REPORT - "NATIONAL SCIENCE FOUNDATION-SUPPORTED SCIENCE EDUCATION MATERIALS: PROBLEMS IN EVALUATION, DISTRIBUTION AND MONITORING"

The specific recommendations and the Foundation's position on each are grouped under the headings: A. Evaluation; B. Distribution; and C. Monitoring. The GAO recommendations are stated first and then the Foundation response.

A. Evaluation

"We recommend that the Director of the Foundation:

1. --Issue a policy statement which will commit the Foundation to the administrative and financial support of the evaluation of educational materials and which will require that Foundation officials become more directly involved in planning and monitoring evaluation activities."

NSF POSITION: The National Science Board Policy Statement of June 1975 requiring a de novo review of pre-college curriculum was a first step toward committing the Foundation to a policy requiring independent evaluation of curriculum materials. The Foundation will extend its policy, appropriately modified, to cover all projects involving the production of curriculum materials for distribution. Such an extension of existing policy clearly implies that NSF officials will be more directly involved in planning and monitoring evaluation activities.

2. "--Develop criteria for evaluating educational materials to aid Foundation officials, materials' developers and evaluators in planning for such evaluations. The criteria should require that consideration be given to the use of subjective and objective test measures, extensiveness of evaluations, evaluations of final versions of education materials, follow-up studies, and independent evaluators."

NSF POSITION: The Foundation will develop strategic guidelines and criteria with the recognition that specific evaluation plans will vary from project to project depending on type, cost, purpose, etc. Program announcements and solicitations will deal explicitly with the Foundation's requirements for project and program evaluation.

3. "--Require through announcements for proposals to develop educational materials that the proposals contain a separate evaluation plan that states materials' objectives in measurable terms and provides an evaluation design to demonstrate whether the objectives have been accomplished, and that the accompanying budget contain a line item showing the cost of evaluation."

NSF POSITION: Requirements for evaluation plans will be included in all future program announcements and guidelines relating to the development of education materials for distribution. Requirements for project evaluations will be determined before funding decisions are made. An evaluation plan--either contained in the project itself or established independently--will be an integral part of the development project. Functional as well as line item budgets will be developed to display clearly the costs of evaluation.

The Foundation intends to assure that materials' purposes are clear and explicit. The Foundation will require the project objectives be more narrowly and precisely stated than in the past. It will support evaluation plans which are relevant to these objectives and reasonably cost-effective in showing whether the objectives have been fulfilled.

4. "--Require a formal evaluation report for all materials developed with Foundation support. The report should be reviewed by Foundation officials for accuracy and completeness and should be available through the distributor as part of the materials package."

NSF POSITION: Evaluation efforts by projects will be monitored and reports reviewed by NSF program officials with respect to clarity, consistency, and reproducibility. However, statements by NSF officials seeming to endorse or guarantee the validity of such reports are not desirable, since given the state-of-the-art, such evaluations carry substantial inherent and irreducible uncertainty.

All evaluation reports supported by NSF funds will be made available to the public through dissemination channels including the ERIC system and NTIS. Given the problem of NSF promoting or appearing to promote materials developed with its support, it does not appear desirable for NSF to require commercial publishers to distribute evaluation reports as part of materials packages in all cases, although publishers are free to do so on their own.

5. "--Insure that the above recommendations are applied to ongoing projects supporting the development of science education materials as well as future projects."

NSF POSITION: The Foundation will review all ongoing projects supporting the development of science education materials and implement the recommendations as appropriate. In some cases, such as in some of the projects included in the December 1975 de novo review, the incremental benefits of additional evaluation efforts may be low. Decisions will be made taking into account these factors.

6. "--If implementation support activities are resumed, including the informational dissemination activities, the evaluation designs and test results for the materials considered for implementation support be reviewed by the Foundation using the evaluation criteria which we are recommending be developed."

NSF POSITION: The Foundation plans no further implementation activities. However, if funds become available for implementation, decisions to implement will take into account evaluation reports whether funded by NSF or not.

B. Distribution Efforts

"We recommend that the Director of the Foundation:

1. --Develop distribution plan requirements for grantees and contractors requesting funds for developing educational materials that will provide data as part of the proposal package to more specifically demonstrate the materials' need and marketability, such as identifying existing materials, their strengths and weaknesses, and how the proposed materials will be an improvement; estimating the intended users and possible barriers to adoption of the materials. This data should be reconsidered as the project progresses and formal market surveys also considered for projects receiving large dollar support."

NSF POSITION: For pre-college educational materials, NSF now does "needs assessment" independently of applicants. NSF plans to obtain some independent assessments of needs whenever it is considering proposals to develop educational materials for distribution. These assessments of need will not be limited to broad requirements of the field but bear specifically on claims about gaps in the market, incremental contributions of new material, etc. Proposers will also be expected to identify existing materials, their strengths and weaknesses, intended users, currently perceived barriers, and so forth.

2. "--Establish procedures for the selection of reviewers to include publishing representatives to review proposals for developing the education materials and to include prospective users and publishing representatives to periodically review the materials during development. The views of users and publishers should be obtained for all ongoing as well as future projects."

NSF POSITION: The direct participation of publishers in the decision chain leading to NSF funding of materials development potentially creates a conflict-of-interest problem concerning bidding and competition. NSF agrees that publisher input into the award decision, review, and evaluation processes is desirable and will investigate ways in which this can be done.

The views of users for all ongoing as well as future projects will be obtained, as required, through such mechanisms as advisory boards for individual projects and ad hoc review panels.

3. "--Develop a system to provide Foundation management with data to assess the impact of educational materials it supports in improving science education."

NSF POSITION: The NSF is in agreement with the substance of this recommendation as it relates to a basic responsibility for monitoring the state of the science education system. Actions along these lines have been taken. For example, one study has been completed and three contracts have been let to ascertain current practice in pre-college science education nationwide.

Assessment of NSF's impact presents persistent problems. The meaning of impact is unclear, since there are many influences on educational performance besides NSF or federally supported educational materials. Discerning the incremental impact of NSF is technically difficult.

Further, there is increasing resistance by the public and the educational community to respond to surveys; publishers regard sales and adoption data as proprietary information; and in-depth analyses are costly. Moreover, assessments of impact and practice need to be coordinated with the efforts of other agencies, e.g., NIE, USOE.

NSF will work on improving techniques for the analysis of impact and will employ systematically those techniques that seem valid, reliable, and reasonably cost-effective.

4. "--Determine the worthiness of the pre-college needs assessment upon its completion for possible application to the higher education activities to promote increased competition for awards and more specific determinations of educational needs."

NSF POSITION: NSF will evaluate the particular approaches taken in the current pre-college needs assessment to determine their generalizability to higher education. Because systems of higher education are highly differentiated, NSF will also consider other approaches.

5. "--Consider establishing a system for the periodic formal assessment of science education needs, upon completion and evaluation of the current planning studies for needs assessment."

NSF POSITION: NSF is in agreement with this recommendation.

C. Monitoring and Reporting

"We recommend that the Director of the Foundation:

--Issue a policy statement regarding the Foundation's role in monitoring ongoing projects that continues to provide for freedom of thought by researchers in conducting their projects, but also provides for more active involvement by Foundation officials as the project is carried out especially when problems are identified.

--Establish guidelines to provide for a more active, systematic monitoring of projects by defining the various monitoring techniques to be used, their frequency of use, and the expected documentation of monitoring activities to be placed in the files.

--Establish monitoring guidelines that consider minimum progress report requirements which include:

(1) an expected frequency for grantees to submit reports;

(2) a standardized report format that considers reporting progress by previously established project milestones which should include targets for various stages of material development, evaluation, and dissemination;

(3) a provision for the program manager to evaluate project progress and document agreements reached with grantees to resolve problem areas; and

(4) circulation of progress reports to higher levels of management within the science education directorate to insure timely and effective action to correct problems on the projects.

NSF POSITION: NSF is in agreement with the substance of this recommendation. NSF's strategic policies and guidelines regarding monitoring and reporting will be formalized in appropriate circulars. As with evaluation, it is the intention of the Foundation to resolve detailed problems and issues regarding monitoring and reporting on a project-by-project basis during the initial proposal review process. Recently improved review procedures are intended, among other things, to assure that crucial preconditions for good project monitoring are met, including existence of a clear project plan, formulation of a clear statement of award conditions and NSF expectations, and formulation of a schedule of performance milestones.

Proper project monitoring does raise some issues requiring further study by NSF, such as the proper allocation of authority and responsibility for making major project changes. In this connection, the advantages, disadvantages, and requirements of operating in the "assistance," "solicitation," and "procurement" modes will be considered, and will enter into subsequent policy determination.

PRINCIPAL NATIONAL SCIENCE FOUNDATION OFFICIALS RESPONSIBLE FOR ADMINISTERING ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DIRECTOR:		
Richard C. Atkinson (acting)	Aug. 1976	Present
H. Guyford Stever	Feb. 1972	Aug. 1976
Raymond L. Bisplinghoff (acting)	Jan. 1972	Jan. 1972
William D. McElroy	July 1969	Jan. 1972
Leland J. Haworth	July 1963	June 1969
Alan T. Waterman	Apr. 1951	June 1963
DEPUTY DIRECTOR: (note a)		
Edward C. Creutz (acting)	Aug. 1976	Present
Richard C. Atkinson	June 1975	Aug. 1976
Lowell J. Paige (acting)	Sept. 1974	June 1975
Raymond L. Bisplinghoff	Oct. 1970	Sept. 1974
Vacant	June 1970	Oct. 1970
Louis Levin (acting)	Aug. 1968	June 1970
John T. Wilson	July 1963	Aug. 1968
ASSISTANT DIRECTOR FOR SCIENCE EDUCATION (note b):		
Harvey A. Averch	Sept. 1976	Present
Harvey A. Averch (acting)	Sept. 1975	Sept. 1976
Lowell J. Paige	Oct. 1973	Aug. 1975
Keith R. Kelson (acting)	Sept. 1971	Oct. 1973
Lloyd G. Humphreys	June 1970	Sept. 1971
Vacant	Oct. 1969	June 1970
ASSOCIATE DIRECTOR (EDUCATION) (note c):		
Thomas D. Fontaine	Aug. 1966	Oct. 1969
Thomas D. Fontaine (acting)	June 1966	Aug. 1966
Henry W. Riecken	Jan. 1965	June 1966
ASSOCIATE DIRECTOR OF SCIENTIFIC PERSONNEL AND EDUCATION (note d):		
Henry W. Riecken	Mar. 1964	Jan. 1965
Bowen C. Dees	Aug. 1963	Mar. 1964
Bowen C. Dees (Assistant Director)	Aug. 1959	Aug. 1963

a/Between July 1961 and July 1963 (when some activities discussed in our report took place) the position of Deputy Director did not exist. The Director designated who would act in his absence.

b/Before July 1975 the title was Assistant Director for Education.

c/Effective October 1969 the Office of Assistant Director for Education was created. In addition to the duties assigned to the newly established positions, the Assistant Director for Education assumed the functions previously assigned to the Associate Director (Education).

d/Effective January 1965 the Office of Associate Director for Education was created. In addition to the duties assigned to the newly established position, the Associate Director for Education assumed the functions previously assigned to the Associate Director for Scientific Personnel and Education.

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